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EDITOR OF THE MONTH

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New York, N. Y.

Printed in U.S.A.

REFRESHER COURSE IN PHYSICAL MEDICINE

December 1, 2 and 3, 1947

UNIVERSITY OF KANSAS MEDICAL CENTER, KANSAS CITY, KANSAS

Postgraduate Medical Study Course of the University of Kansas School of Medicine in cooperation with Kansas Medical Society and the Kansas State Board of Health.

Monday, December 1st.

8:00 A.M. Registration.

9:00 A.M. **Physical medicine in the treatment of arthritis.**

Medical aspects: DR. WILLIAM H. GOODSON, JR.

Orthopedic aspects: DR. NICHOLAS S. PICKARD.

10:00 A.M. **The present status of artificial fever Therapy.**
DR. H. WORLEY KENDELL.

11:00 A.M. **Therapeutic exercise.**
War department sound motion picture.

11:50 A.M. **Recess.**

12:00 M. **The application of the principles of instrumentation to physical medicine.**
DR. KENNETH E. JOCHIM.

1:00 P.M. **Luncheon period.**

2:00 P.M. **The clinical application and significance of electromyography.**
DR. KENNETH E. JOCHIM and DR. DONALD L. ROSE.

3:00 P.M. **The joint application of physical therapy and occupational therapy in physical medicine.**
DR. H. WORLEY KENDELL.

Tuesday, December 2nd.

9:00 A.M. **The importance of simple muscle testing procedures in a general medical examination.**
DR. DONALD L. ROSE.

10:00 A.M. **Physical medicine in the treatment of vascular diseases.**
DR. DON C. PEETE.

10:50 A.M. **Recess.**

11:00 A.M. **Physical medicine and the hemiplegic.**
DR. HAROLD DINKEN.

12:00.M. **Physical medicine and the general treatment program of poliomyelitis.**
DR. HERBERT C. MILLER.

1:00.P.M. **Luncheon period.**

2:00 P.M. **Physical medicine in disabilities of the aged.**
DR. HAROLD DINKEN.

3:00 P.M. **The teaching of crutch walking: Demonstration.**
DR. DONALD L. ROSE and MRS. RUTH G. MONTEITH.

Wednesday, December 3rd.

9:00 A.M. **The role of physical medicine in the treatment of thoracic diseases.**
DR. PAUL W. SCHAFER.

10:00 A.M. **The physiologic basis for therapeutic exercise.**
DR. EARL C. ELKINS.

11:00 A.M. **The use of physical procedures in orthopedic conditions.**
DR. JAMES B. WEAVER.

11:50 A.M. **Recess.**

12:00 M. **Rehabilitation in orthopedic conditions.**
DR. REX L. DIVELEY.

1:00 P.M. **Luncheon period.**

2:00 P.M. **The application of physical therapy, occupational therapy and rehabilitation procedures in general practice.**
DR. EARL C. ELKINS.

3:00 P.M. **The treatment of cerebral palsy.**

Medical aspects: DR. ROBERT E. BRUNER.

Technical aspects: MISS RUTH KENNETT, MISS ELIZABETH DENTON, MISS MILDRED HATFIELD, MRS. ALICE CLARK.

For enrollment blanks and further information address Dr. Donald L. Rose, Department of Physical Medicine or Postgraduate Study Course, University of Kansas School of Medicine, Kansas City 3, Kansas.

MANIPULATION OF STIFF JOINTS

JAMES MENNELL, M.D. (CANTAB.)

LONDON, ENGLAND

It has been possible to develop the science and art of joint manipulation only since it has become possible to study the living anatomy of joints. Till that time arrived, joint manipulation was more or less haphazard and was, therefore, unpopular and remained undeveloped so far as medical practitioners as a whole were concerned. Then the trouble arose that when the science seemed to lay the way open the art had still to be developed, and it was during this stage that the whole proceeding fell into disrepute again because of faulty technic. There are certain rules which must be obeyed if any form of medical treatment is to lead to success; the object in view in preparing this article has been to state these laws and to try to explain the reasons for their existence.

Pathologic Considerations

There are obviously certain types of joints in which there is definite limitation of movement but yet in which manipulation should be scrupulously avoided. Prominent among these are joints whose range of motion is limited by tuberculous infections. Once the disease is well established, few persons would make the mistake of trying to treat the articular condition thus, but in the earliest stages, particularly, if trauma has preceded the onset fairly recently, doubt may readily arise unless one outstanding principle is observed.

The great difficulty is to decide whether the limitation of movement in any joint is due to present active inflammation or whether it is a result of past inflammation which is now quiescent. Personal judgment based on experience is the final test, but there is one feature that should always be regarded as taking a paramount place in the history. Putting aside altogether obviously acute inflammation, there are many doubtful cases, and some general guiding rule is essential.

Pain after rest which improves temporarily as the result of movement should always arouse suspicion that a subacute inflammatory condition is present. Pain that improves with rest and increases in direct proportion with subsequent activity may usually be accepted as an indication that the inflammatory condition has become, at least to a large extent, quiescent; and that the time has come when manipulation may be considered as a possible line of treatment.

Take for example, the earliest stages of spondylitis of the type that unless adequate treatment is provided, will spread on to the development of a so-called poker spine. The patient is usually a young athlete, who will often attribute the somewhat slight pain that is so commonly noted in the early morning, with a feeling of stiffness, to a slight strain or injury while engaged in his favorite pastime and may even attribute it to some one particular action. There may also at first be only such trivial limitation of movement during the day that the patient ignores it altogether; but, in response to close questioning, it is found that he is always more conscious of stiffness on waking in the morning than at any other time during the day. Even by the time he is ready for breakfast he may be unaware of any trace of active trouble. When the condition fails to improve, he may then seek advice, particularly if he finds that his skill at his favorite sport or pastime is suf-

fering from what he considers to be loss of technic. To use manipulation can only lead to further deterioration, whereas the active condition can be checked at any stage to which it may have extended by the use of wide field roentgen therapy. High voltage roentgen therapy will usually relieve the pain but it often fails to check the disease, whereas the use of wide field roentgen therapy is successful in both though more slow in easing the pain.

If the symptoms of stiffness of pain, or of both after rest has disappeared but the symptoms still return with activity, all other causes must be eliminated before the advisability of manipulation is considered. Most, if not all, persons with spondylitis have a certain loss of elasticity of the soft structures, and if this affects the iliotibial bands symptoms will almost invariably remain until the elasticity in these structures has been restored. Once this is done and all other possible sources of active inflammation have been eliminated, then one may consider loosening the joints.

Another fairly safe test for active inflammation within the joint is to compress the two joint surfaces up against one another. If active inflammation is present, this procedure may cause acute pain, whereas in the absence of an acute inflammatory condition it will not do so. This test applies particularly to the shoulder, where doubt very commonly arises. If, however, pressing the head of the humerus up against the glenoid fossa in a vertical direction causes pain, it is never wise to consider a set manipulation until a period of complete rest has allowed the condition to quiet down.

There is yet a third point worthy of consideration, particularly when the knee joint is concerned. By pressing on the lower pole of the patella in one particular degree of flexion, a synovial squeak may be elicited, which can be elicited in no other position; this may be taken to indicate an inflammed condition of the infrapatellar pad of fat and is usually associated with limitation of movement in both flexion and extension. Despite the active inflammation, manipulation of the joint is justifiable, provided that the restoration of movement in the direction of flexion only is attained. No attempt to obtain free extension is justifiable unless the restoration of flexion also restores the extension. The inflammatory condition is often due to the nipping of the fatty pad between the two bones. Adhesions form and its mobility is thereby impaired, leading to a constant repetition of the nipping. This mobility may be restored by flexion, but any attempt at forced extension is almost certain to lead to a further nipping, often with disastrous consequences.

Having, therefore, decided after mature deliberation that restoration of lost mobility is desirable, a roentgen examination should be regarded as essential in order to exclude bone disease. This is particularly important when considering the joints of the spinal column, as a deficiency in bone salts may be present to an extent that would render manipulation positively dangerous. Recurrent attacks of severe pain are often due to microscopic crush fractures of the bodies of the vertebrae, and until the salts have been restored (by the daily use of general ultraviolet radiation for six months combined with irradiated ergosterol three times a day) any attempt at restoration of movement should be postponed. After this treatment, it is usually found unnecessary to consider restoration of mobility. The technic of irradiation is a special one, consisting of exposure of the whole of the front and back to the light for one minute. The dose is increased daily by the addition of one minute only each day until the first sign of desquamation or tanning is visible. At the very first sign of either, treatment should cease entirely until the reaction is no longer visible and it should then be resumed with a decreasing dosage, obtained by increasing the distance of the lamp. This is also the treatment of choice for Paget's disease.

Anatomic Considerations

At every joint of the body there is some movement that the therapist can perform for the patient which the patient is completely unable to perform for himself. An obvious example is tension. The number of movements which are outside voluntary control vary at individual joints. At the hip joint, for example, tension is probably the only activity that comes outside voluntary control, whereas at the joints of the digits of hand and foot there are at least six involuntary movements. There is never any justification for attempting to restore lost ability to perform movements that are under voluntary control until those that are not so have been completely restored.

Then, too, the exact nature of the movement that takes place at each joint must be studied, not from the ordinary description in anatomic textbooks but by study of the shape of the two contiguous surfaces. Wherever cartilage is visible at the end of a bone, it is there for some definite purpose—that the cartilage on the surface of one bone may be free to move over the whole of the surface of the other cartilage. This may involve what appears to be hypermobility, but the ordinary limit of movement varies considerably in each individual, with the result that it is often difficult to judge whether an apparent limitation is within the limits of the normal. Fortunately, there is usually some joint on the opposite side which can be used for comparison. When there is not, judgment and guess work must be employed in making a decision.

It is not uncommon, for instance, for the joint surface on the head of a metacarpal to extend on to the dorsal surface, indicating that full extension has not been reached until perhaps an angle closely approaching 45 degrees of hyperextension has been reached. Anatomically, therefore, when the fingers are held out in a straight line with the metacarpal bones, a degree of flexion has already taken place, a mounting in exaggerated cases to as much as 45 degrees.

Another important point which can readily be demonstrated by roentgen examination is that the old anatomic description of certain joint movements must be revised, to some extent at any rate. The idea of dorsiflexion and palmar flexion of the wrist joints is now no longer tenable, as the movement of dorsiflexion of the hand takes place mainly at the intercarpal joint and palmar flexion, mainly at the true wrist joint, i. e., the radiomeniscocarpal joint. Full range of movement of the hand, if mobility has not been restored at both these joints, will lead only to undue strain. Perhaps the most remarkable of these anatomic studies is the movement of the radioulnar joints, as it can be proved roentgenographically that the head of the radius is in firm contact with the lower end of the humerus only in full extension (this may be only in full hyperextension) and in full flexion. Thus it comes about that a free movement of the radius in the long axis of the forearm is a reality, and this has a large bearing upon the manipulation of these joints. A sudden pull on the hand may cause a definite locking of the joints, which, in turn, causes marked disability, and this can be overcome by the simple process of pressing the radius upwards. If a similar condition has arisen, as the result of a fall on the outstretched hand and the radius has been pushed upward in the long axis of the forearm, tension will bring a relief, which is often complete and instantaneous.

The old anatomic descriptions of the movements of the shoulder and hip joints are almost identical, yet the acetabulum is circular and the glenoid fossa is pear shaped. The reason for this is that when the humerus moves on the glenoid there is considerable backward and downward gliding of the

humerus; if this gliding movement is limited, the upper end of the humerus is not free to glide under the overhanging acromion. If the movement is forced before the gliding movement is restored, a severe nipping of the soft structures between the humerus and acromion will render the last condition worse than the first.

Technic

In all attempts to manipulate a joint, the first essential is to know which joint is at fault. This may sound simple, but it is well known that many patients seek advice for pain or loss of function in the knee joint, whereas it is the hip joint which is the source of trouble and the knee joint is normal. So, too, it is not uncommon for patients to complain of pain in the shoulder joint region, when in reality it can easily be demonstrated (provided the examination is made with the patient in the recumbent position) that the pain which causes the disability is referred from the third, fourth, fifth or sixth cervical segment of the spine. So, too, after an old injury, pain may exist in the ankle region, despite of the fact that complete recovery has been made. In this event it will often be found that the mobility of the superior tibiofibular joint is deficient, and if this mobility is restored the disability which was attributed to the ankle region will disappear. In the joints of the spine, the difficulty is often greater still, and symptoms attributable for instance, to the fourth lumbar nerve root may in reality owe their origin to lack of proper functioning of the joints connected with the second lumbar vertebra. So, too, symptoms which may appear to arise in the sacroiliac joints may really arise from the lumbosacral joints or even, from abnormal joint formation in association with a sacralized fifth lumbar vertebrae or even, very occasionally, from a lumbarized first sacral vertebra. In case of the joints of the back, every joint in the neighborhood must be examined for loss of mobility in every direction and the findings recorded as plus or minus. At the end of the examination, the pluses are balanced carefully against the minuses. Then, if an error is made, at least everything has been done to prevent it.

After it has been decided that a joint is deficient in mobility and that it is wise to restore it, there is one golden rule that must never be neglected: to secure, as far as is possible, absolute fixation of the bone on one side of the joint before moving the joint surface of the other bone upon it. If this precaution is neglected, it is likely that mobility at the affected joint will not be restored and added strain may make the condition worse. Having fixed the bone on one side of the joint, before the attempt is made to move the other, a grip must be taken which will enable one to perform the movement desired. This grip, of course, varies with every movement. Then, before the movement is performed it is essential to take up the slack (to use a nautical expression), which means that the desired movement is performed until no further movement is possible. Then, according to the nature of the movement desired, one either pushes or pulls. Even these words scarcely describe the action, which more nearly amounts to thrusting or tugging. In other words, once the apparent limitation of movement is reached, the last bit that can be regained is secured by the administration of a certain force, which must, of necessity, be well under control. Then, when all the movements which are not under voluntary control have been freed, those that are under voluntary control may be restored, provided that there is no friction between the conception of the two types of movement.

There is a somewhat acute divergence of opinion as to whether full range is to be restored at one sitting. This, of course, must depend upon the amount of lost mobility that requires restoration. If it is great, it is

usually wiser to pass the first dead point and stop and then pass on to restoration of movements in other directions, stopping again as each dead point is overcome. It is true that this may mean that a subsequent manipulation may be required, say in a month's time. But, on the other hand, a severe reaction in the form of pain is avoided. If much pain is present, subsequently the instinct of self preservation is liable to assert itself and prevent the patient from maintaining the mobility that has been restored. Adhesions will again form, and the whole process then requires repetition. Other persons believe that if a joint is moved under anesthetic it should be put through its full range of movement. Obviously, if the limitation is slight this is the correct objective; but if the limitation is gross, one must avoid doing harm and it is always wise to err on the side of caution. This particularly applies to manipulation of the elbow joint, where to force movement after the first dead point is past will often lead to damage to the periosteun, leading to massive new bone formation. This is due to the fact that ligaments are attached to a very thin stratum of hard bone, which gives away long before the ligaments or adhesions on stretching.

Leverage should always be as short as possible. The application of considerable force by means of long leverage is always dangerous, as there is usually, some weakening of the bone after prolonged immobility. Also, unless leverage is very short, it is always difficult to be certain that the movements which are under voluntary control are being performed with an adequate degree of the involuntary movements. It should be needless to add that in performing the movements which are under voluntary control, it is essential to have an exact knowledge of what these movements really consist in. In the hand, for example, flexion or extension of the digits consists in a gliding movement of the base of the distal bone around the head of the proximal. Anyone can bend or extend a stiff finger; but unless this gliding movement takes place, the bending or straining may take place through the shaft of the bone rather than in the joint. Similarly, at the hip joint it is easy to secure a full range of movement through the neck of the femur instead of at the hip joint.

When one is asked what movements should be performed at a joint after a set manipulation has been performed, the only answer is that the technic should be identical whether the manipulation is carried out with or without an anesthetic. The only difference concerns the range through which the joint is to be put. Here, again, is controversy, but the range of movement must depend upon the extent of the reaction. No new adhesions are formed within two or three days; consequently a general guiding rule is that one need not of necessity secure the full range of movement secured under the anesthetic within a week or so of the manipulation. The only guide is pain, and if this is severe the restoration of the voluntary movement will be impossible.

Summary

1. The living anatomy of joints is an essential study for persons who wish to undertake joint manipulation.

2. The exact diagnosis of the condition present is essential before one should try to restore mobility at any time by forced movement.

3. The laws of anatomy and physiology must be applied to any and every movement performed, and the movements that are not under voluntary control must be secured before those that are voluntarily controlled.

4. The movement of every joint in the body requires a special technic, and unless this technic is scientifically acquired more harm than good is likely to be done.

FUNCTIONAL CHANGES IN MUSCLE AND NERVE RESULTING FROM PROLONGED STATES OF SHORTENING *

NORMA M. HAJEK, M.S.

M. E. GODBEY

and

H. M. HINES, Ph.D.

IOWA CITY

Excessive and prolonged shortening of skeletal muscle is associated with changes in its properties whereby the muscle becomes set at a new length and fails to return to its original length during relaxation. This condition of muscle has been referred to by Ramsey and Street[1] as the "delta" state. The clinical and experimental conditions in which marked and prolonged muscle shortening occurs are numerous and result from such conditions as tenotomy, immobilization in a shortened state by means of casts or other mechanical restraint, loss of a normal stretching force from the paralysis of antagonist muscles or following the local injection of tetanus toxin. Muscular shortening may be found in lesser degree in association with the spastic states which are common to certain lesions of the central nervous system, such as the muscle spasms in acute poliomyelitis.

This report is concerned with a quantitative study of the functional damage to muscle which occurs during states of prolonged shortening and with methods for graduating the degree of muscle impairment. Two methods were employed to produce muscle shortening. One was by a section of its tendon, and the other was by the local injection of tetanus toxin. Skeletal muscle has been found to undergo functional[2] and morphologic[3] changes after tenotomy. These include shortening of the fibers, atrophy and loss of contractile strength. Ranson and co-workers[4] have shown that the injection of tetanus toxin into the popliteal space or into the thigh muscles near this area is followed by a shortening of the extensor muscles of that leg, and, if the dose of toxin is not too large, it is without effect upon the muscles of the contralateral limb. This condition is referred to as local tetanus and usually makes its initial appearance at about three days after injection of the toxin. Soon thereafter maximal extension of the ankle and hip is noted and a maximal rigidity of the extensor muscles of that limb occurs. The muscle shortening at this time is believed to be of the nature of a true tetanus inasmuch as it is dependent upon motor nerve impulses and disappears either after section of the motor nerve or during deep anesthesia. However, if this shortened state persists for several days the muscle becomes set at this shortened length and then fails to relax even after section of its motor nerve. According to some investigators,[5] the initial local tetanus is due to an action of the toxin upon the anterior horn cells; while others[6] believe that in addi-

* From the Department of Physiology, State University of Iowa.

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1. Ramsey, R. W., and Street, S. F.: Muscle Function as Studied in Single Muscle Fibers, Biol. Symp. 3:9, 1941.
2. Knowlton, G. C., and Hines, H. M.: The Effects of Growth and Atrophy Upon the Strength of Skeletal Muscle, Am. J. Physiol. 128:521 (Feb.) 1940.
3. Davenport, H. K., and Ranson, S. W.: Contracture Resulting from Tenotomy, Arch. Surg. 21: 995 (Dec.) 1930.
4. Ranson, S. W., and Sams, C. F. The Permanent Shortening of Muscle Caused by Tenotomy and Tetanus Toxin, J. Neurol. & Psychopath. 8:304 (April) 1928.
5. Acheson, G. H.; Ratnoff, O. D., and Schoenbach, E. B.: The Localized Action on the Spinal Cord of Intramuscularly Injected Tetanus Toxin, J. Exper. Med. 75:465 (May) 1942.
6. Harvey, A. M.: The Peripheral Action of Tetanus Toxin, J. Physiol. 96:348 (Aug.) 1939.

tion there is a direct effect of the toxin upon either the muscle or its end plates.

The order of events in a group of animals receiving injections of tetanus toxin is such as to permit a study of neuromuscular function prior to the onset of tetanus, during the times when it is abolished by nerve section or anesthesia, after the muscle has become set at a new length and later, when recovery is in progress.

Experimental Procedures

The studies were carried out on the gastrocnemius muscles and tibial nerves of adult rats. All operations, injections and measurements except temperature determinations were carried out with the animals under ether anesthesia. Tenotomy was performed by clipping off the exposed os calcis, freeing the tendon from all other bony attachments and sewing the end of the tendon into the skin. This procedure made it possible to preserve a length of tendon suitable for the attachment of the muscle to a tension lever for subsequent strength measurements. A freshly diluted solution of tetanus toxin was injected into the popliteal space of one limb and an equal volume of physiologic saline solution into its contralateral limb as a control. The strength of the stock tetanus toxin had been determined by assay in preliminary experiments. A "full" dose represents the minimal amount of toxin which was required to effect extreme rigidity in the gastrocnemius muscle of the injected limb and which would not affect the muscles of the contralateral control limb. Smaller doses of the toxin are expressed in fractions of the full dose.

Muscle strength was considered to be the maximal tension developed in response to stimulation either of the muscle or of its motor nerve. For this purpose the exposed tendon of Achilles was cut and attached to a Blix type torsion rod. A portion of the femur was exposed and fixed in a rigid clamp. The intact muscle was directly stimulated through two needle electrodes which pierced it, one at the tendon and the other at the origin. Adjustable insulated silver electrodes were placed in contact with the tibial nerve for indirect stimulation. Short volleys of slightly supramaximal stimuli, either from an inductorium or as condenser discharges, were delivered to the muscle and nerve. The stimulus pattern and initial muscle tension adjustments were those which in previous experiments had been found optimum for maximum tetanus tension development. The extent of muscle shortening was measured from optical records. At the conclusion of the strength measurements, the gastrocnemius muscles were carefully dissected out and weighed. Muscle weight and strength measurements were taken of animals sacrificed at 3, 7, 14, 21, 28, 49 and 100 days after injection of the tetanus toxin and at 14 days after tenotomy.

The temperatures of the experimental and contralateral control muscles were determined in a group of animals at 14 days after toxin injection and in a group 14 days after tenotomy. This was done by means of a thermocouple which was housed in a hypodermic needle and inserted into the belly of the gastrocnemius.

Results

The average values obtained from studies on 143 animals at various times after the injection of a "full" dose of tetanus toxin are presented in chart 1. Normal values were found for the weight and strength of the experimental gastrocnemius muscles in the studies made at seventy-two hours after injection of toxin. No appreciable amount of local tetanus and shortening existed in these muscles prior to this time. Evidence for muscle damage was found in the studies made as early as seven days after administration of toxin and from three to four days after the onset of marked and persistent shortening in the experimental gastrocnemius muscles. The muscular impairment was progressive and became most marked at about twenty-one days after injection of toxin. The damage to muscle was characterized by atrophy and loss of strength. The latter was due in part to atrophy and in part to functional impairment as was evidenced by the finding of a lesser isometric tension response per unit weight of tissue. After three or four weeks the marked rigidity in the extensor muscles began to subside and normal movement patterns to return. The improvements in position

and mobility of the limb were paralleled by an increase in the strength and mass of the affected muscles. It is to be noted that the regeneration of muscle mass was slower than the recovery of contractile strength per unit mass of tissue. The data from the individual experiments reveal remarkably consistent and uniform responses to injection of toxin in the different animals. The ratio of the isometric tension elicited by motor nerve stimulation

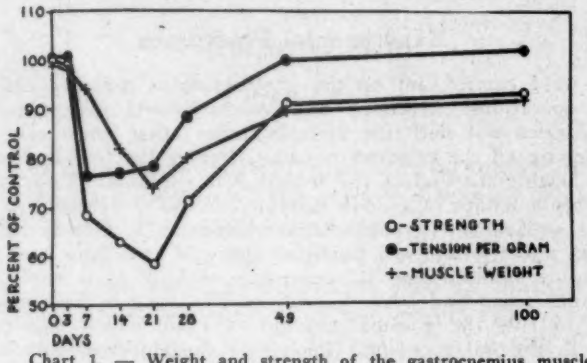

Chart 1. — Weight and strength of the gastrocnemius muscle of the rat at various times after injection of tetanus toxin.

to that elicited by direct muscle stimulation was slightly but significantly higher in the experimental muscles than in their normal contralateral controls (table 1). Varying degrees of muscle damage resulted from different doses of tetanus toxin. The data (chart 2) show that one-fourth of a full dosage caused only a slight diminution in muscle weight and strength,

TABLE 1. — *Summary of Average Values for the Ratios of the Tensions Developed by Nerve Stimulation to Those Developed by Direct Stimulation in Tetanus Toxin and Contralateral Control Gastrocnemius Muscles.*

No. of Animals	Days After Toxin	Tension Nerve Stimulation / Tension Muscle Stimulation	
		Toxin Per Cent	Control Per Cent
6	3	95.6	94.1
16	7	97.8	93.5
32	14	97.0	92.2
10	21	96.9	94.3
8	28	95.8	93.1
12	49	95.5	94.5
11	100	92.2	94.0
Mean-all	.....	95.9	93.3
S. D.	.....	4.8	4.8
S. E. (diff.)	.....	0.697	....

while a one-half dose resulted in a degree of muscle damage midway between that found for the one-fourth and "full" doses.

The gastrocnemius muscles which underwent prolonged shortening following tenotomy showed changes comparable in kind to those observed in the tetanus toxin experiments (chart 3). However, the degree of atrophy and functional damage was greater in the muscles which exhibited shortening following tenotomy than in those which shorten after injections of tetanus toxin. The temperatures of the muscles in a shortened state resulting from either tetanus toxin or tenotomy were lower than those of their normal contralateral controls (table 2).

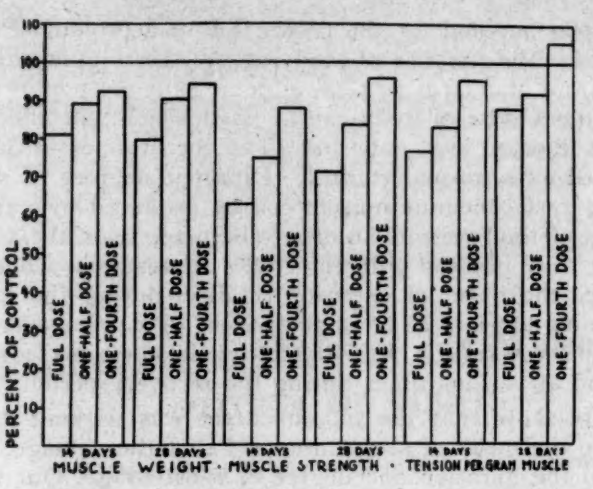

Chart 2. — Effects of different dosages of tetanus toxin on weight and strength of the gastrocnemius muscle of the rat.

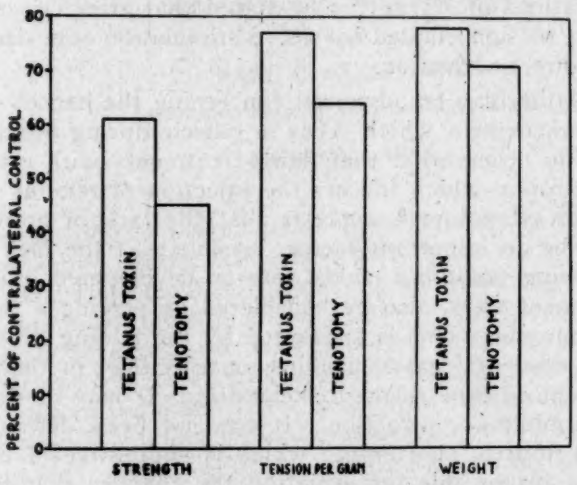

Chart 3. — Comparison of the effects of shortening due to tetanus toxin and to tenotomy on skeletal muscle.

TABLE 2. — *Average Values for the Temperatures of the Control and Experimental Gastrocnemius Muscles of Rats at Fourteen Days Following Tenotomy and at Fourteen Days After Injection of Tetanus Toxin.*

	Tetanus Toxin	Tenotomy
Number of animals	22	8
Mean contralateral control	37.42° C.	37.94° C.
Mean experimental	37.06	37.08
Average difference	0.286	0.87
S. D. (diff.)	0.280	0.604
S. E. (diff.)	0.060	0.211

Comment and Conclusions

Functional damage to skeletal muscle results from the state of prolonged shortening which follows either tenotomy or local injection of tetanus toxin. Such muscles exhibit atrophy, diminution of strength and subnormal temperature. These changes can be considered as reversible, inasmuch as the affected muscles eventually regain their normal functional patterns and much of their weight and strength.

A satisfactory method for the production of a prolonged state of shortening suitable for the purpose of studying its effects upon muscle is offered by the injection of standardized tetanus toxin into the popliteal space of one limb of the rat. A dose of toxin can be used which will affect the extensor muscles of the injected limb only and allow the muscles of the contralateral limb to be used as a normal control. Different degrees of shortening and damage to the gastrocnemius muscle can be produced by varying the dose of toxin. This method permits studies to be made upon the affected muscles at times when they present different stages of reaction. These include intervals prior to the onset of extensor rigidity, during the period that the muscle shortening appears to be of the nature of a reflex tetanus which can be abolished by nerve section, after the muscle has become set at a new shortened length and at various times during the recovery period.

The results show that the tetanus toxin was without effect upon the muscle prior to the onset of shortening and that the damage to muscle was proportional to the duration and degree of shortening. Our findings are in accord with the conclusions of Ranson and Sams[4] in that tetanus toxin did not interfere with neuromuscular transmission, but are difficult to reconcile with the observations of Harvey,[6] who stated that after injection of tetanus toxin the twitch tension elicited by nerve stimulation was considerably less than that from direct activation.

Only speculation can be advanced concerning the causes of the atrophy and functional impairment which occur in muscle during prolonged states of shortening. The observation that daily treatments with electrical stimuli will delay the atrophy which follows the injection of tetanus toxin[7] but not that which follows tenotomy[8] suggests that the lack of active tension development may be an important factor, inasmuch as the lack of muscle attachments following tenotomy makes tension development impossible. Circulatory impairment must also be considered as playing a possible role in the damage to muscle. This is suggested by the finding of lower temperatures in the experimental gastrocnemius muscles than in their controls and by the fact that blood flow through skeletal muscle may be decreased or arrested during a tetanic contraction. It has not been determined to what extent the early muscle shortening, which is suggestive of a reflex hyperactivity, may be responsible for initiating the changes that lead ultimately to the setting of the muscle at a new shortened length. If this should prove to be an important factor, it would follow that the ultimate damage to muscle could be lessened by measures which reduce the extent of reflex activity.

Summary

A study was made of the effects of prolonged states of shortening upon the functional characteristics of the gastrocnemius muscle of the rat. The state of muscle shortening was produced either by tenotomy or by the local injection of tetanus toxin and was associated with a gradual loss of muscle weight and strength and with a subnormal muscle temperature. The muscle weakness was due in part to atrophy and in part to damage to the tension-developing mechanisms. These changes were reversible in that the affected muscles ultimately regained their normal functional patterns and most of their weight and strength.

The local injection of tetanus toxin proved to be a consistent and reliable method for the production of shortened states in muscle. The dose

7. Hajek, N. M., and Hines, H. M.: Experimental Treatment of Muscle Spasticity, Fed. Proc. 6: 119 (March) 1947.
8. Wehrmacher, W. H.: Thomson, J. D., and Hines, H. M.: Effect of Electrical Stimulation on Denervated Skeletal Muscle, Arch. Phys. Med. 26:261 (May) 1945.

of toxin could be graded so as to produce different degrees of muscle damage. Its use permitted studies to be made upon the affected muscles prior to the onset of extensor rigidity, during the period at which the shortening was of the nature of reflex tetanus, after the muscle had become set at a new shortened length and at various times during the recovery period. No evidence was found that tetanus toxin caused impairment of neuromuscular transmission or affected muscles prior to the onset of extensor rigidity.

AN OPTICAL GONIOMETER FOR OBSERVING RANGE OF MOTION OF JOINTS

A Preliminary Report of a New Instrument

HARRY A. WILMER, M.D., Ph.D.
Fellow in Medicine, Mayo Foundation
and
EARL C. ELKINS, M.D.
Section on Physical Medicine, Mayo Clinic
ROCHESTER, MINN.

When one person makes serial measurements of range of motion of a joint, the readings usually are consistent. However, when another observer, using the same instrument on the same patient, attempts to determine range of motion, the measurements are often at great variance, particularly if he is unaware of the readings previously obtained. Employing the common goniometer, observers frequently find results 10 to 20 degrees apart. This violates a cardinal rule of the quantitative method of measurement, in that the facts are not reproducible under ordinary circumstances by a second observer.

The inherent error due to the construction of any of the ordinary goniometers of the protractor type is negligible. The large error is usually in its application and interpretation. The weight of the observer's hands, the force with which he assists motion of the part and the patient's or the observer's conscious or subconscious desire to exceed the measurements last recorded, as well as the difficulties attendant on the actual fitting of the instrument to the limb and the uncertainties in reading it, constitute the most obvious sources of error. These instruments are usually calibrated in 5 and 10 degrees and are not considered to be accurate to less than 10 degrees. As a matter of fact, if they were accurate and reproducible within this range, they would be highly satisfactory. It should be emphasized that for clinical use this degree of accuracy is adequate. In experienced hands such accuracy may be attained, particularly when measurements are always made by the same person.

There is need for a simple instrument of equal or greater accuracy which will allow different observers, even relatively unskilled, to make reproducible observations. There can be no substitute for care and rigorous control of conditions under which such calibrated instruments are used. In the belief that such an instrument should probably employ a visual image, the "sighting principle" has been used in a new optical goniometer described in this

paper. Results of testing this instrument against known angles drawn on paper or the blackboard are reported.

Literature

Minor variations and improvements of the common goniometer are reported in the literature with rare departure into original devices. Many instruments are not used because they are expensive, cumbersome or not readily obtainable or made.

Wiechec and Krusen[1] described a method of measurement of joints and reviewed the literature up to 1939. Illustrations of important devices can be found in their paper. The various protractors described are essentially modifications of the common goniometer.

Albee and Gilliland[2] described a complicated instrument for the measurement of voluntary movement. They recommended separate and cumbersome apparatus for the fingers, wrist, forearm, elbow, shoulder and knee, and two for the ankle. The equipment for the shoulder abduction-adduction recording was almost as large as the patient. Most of the devices had to be actually secured or shackled to the limb being measured.

Rosén[3] described a modification of the common goniometer and another instrument for measuring finger motion. Schlaaff[4] described a complicated appliance for estimating angles of the finger joints. Neither of these implements for observing excursions of a finger joint is as satisfactory as the common machinist's angle measure (fig. 1), which is in mass production in this country. Clark[5] described a protractor for determining rotation of joints. Various plain or collapsible "fleximeters" have been described.[6] One author[7] described four large complicated devices for observing movement of the ankle, foot, knee, elbow and wrist, and circular movements of the radius, including pronation and supination. A "flexo-extensometer,"[8] a "universal goniometer"[9] and a "recording arthroflexometer"[10] are complicated and expensive. This is true to a lesser extent of the protractor with long arm and stand with hinged upright.[11] A "pendulum arthrometer," such as described by Hand,[12] had appeared previously in the literature. A specially graduated semicircle of light metal with two pointers running on a circle was recently devised by Grunbaum,[13] but, unfortunately, he published no illustration and the description is too brief to be clear.

Optical Goniometer

A reducing lens, which is the opposite of a magnifying lens, is the basis of the optical measuring device. A transparent scale of 360 degrees (fig. 2) is attached to the glass lens. When one looks through the lens and scale at the limb, the reduced image of the limb appears on the scale. This embodies the photographic concept of an image, and, provided the instrument

1. Wiechec, F. J., and Krusen, F. H.: A New Method of Joint Measurement and a Review of the Literature, Am. J. Surg. 43:659, 1939.
2. Albee, F. H., and Gilliland, A. R.: Metrotherapy, or the Measure of Voluntary Movements; Its Value in Surgical Reconstruction, J. A. M. A. 75:983, 1920.
3. Rosén, N. G.: A Simplified Method of Measuring Amplitude of Motion in Joints, J. Bone & Joint Surg. 20:570, 1922.
4. Schlaaff, Johannes: Der Messfächer, ein Zwangsmass zu einheitlicher Gelenkmessung, Zentralbl. f. Chir. 64:1354, 1937; Der Messfächer, München. med. Wchnschr. 85:369, 1938; Der Finger-Fächer, Zentralbl. f. chir. 66:1078, 1939.
5. Clark, W. A.: A Protractor for Measuring Rotation of Joints, J. Orthop. Surg. 3:154, 1921; A System of Joint Measurements, ibid. 2:687, 1920.
6. Robinson, W. H.: Joint Range, J. Orthop. Surg. 3:41, 1921.
7. Gifford, H. C.: Instruments for Measuring Joint Movements and Deformities in Fracture Treatment, Am. J. Surg. 28:237, 1914.
8. Conwell, H. E.: Flexo-extensometer, Surg., Gynec. & Obst. 40:710, 1925.
9. Alquier, L.: Un nouveau goniomètre médical, Paris méd. 23:413, 1917.
10. Parker, J. S.: Recording Arthroflexometer, J. Bone & Joint Surg. 27:126, 1929.
11. Silver, D.: Measurement of the Range of Motion in Joints, J. Bone & Joint Surg. 21:569, 1923.
12. Hand, J. G.: A Compact Pendulum Arthrometer, J. Bone & Joint Surg. 30:495, 1938.
13. Grunbaum, Roberto: Un dispositivo simple para medir angulos de las articulaciones, Día méd. 16:1280, 1944.

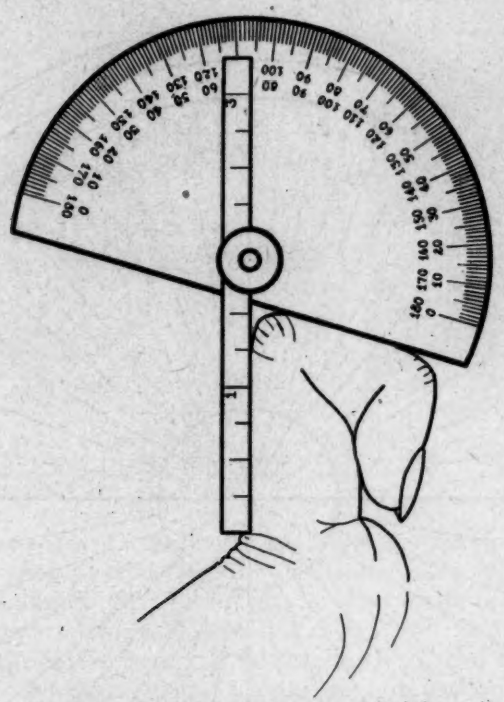

Fig. 1. — One type of common machinist's angle measure which is in mass production. This instrument can be employed to make accurate observations of range of motion of finger joints. The rule arm slides through a central pivot point with either arm shortened as desired. The rule is usually 6 inches (15 cm.) long, but it can be cut in half as illustrated.

is held correctly, different observers will see the same image on the same scale. Three large dots are made on the skin with ink, wax pencil or silver nitrate. One mark is made over what appears to be the center of motion of the joint and the other two above and below the joint, over bony landmarks which are, as nearly as it is possible to ascertain, opposite the longitudinal axis of the bones articulating in the joint.

For this study, a planoconcave reducing lens 2½ inches (6.4 cm.) in diameter, of —10 D. power, was used. This was the only reducing lens available until recently a double concave reducing lens 3 inches (7.6 cm.) in diameter and having a focal length of 6 inches (15.2 cm.) was obtained. The larger lens with a correspondingly larger transparent scale mounted in a double-handled aluminum frame is preferable to the smaller apparatus (figs. 3 and 4). The larger scale and better holding arms permit easier reading of angles. Nevertheless, the results obtained with the smaller lens are being reported.

The instruments were constructed as follows: A suitable scale of 360 degrees (fig. 2) was drawn, reduced to a diameter equal to that of the lens and printed on a photographic transparency. The outer two circles are guides for measuring the diameter of the transparency and give an accurate mark for cutting the circle from the remainder of the transparency. The cut-out scale is covered by a piece of plain glass 1/8 inch (3 mm.) in thickness cut to the same diameter as the lens. The scale faces the side of the lens through which one looks, so that it is not distorted by reduction. On the opposite side of the lens one may place a photographic transparency with a small dot or circle in the center (fig. 5). It is not absolutely necessary to use this transparency with the dot or circle. This likewise is protected by

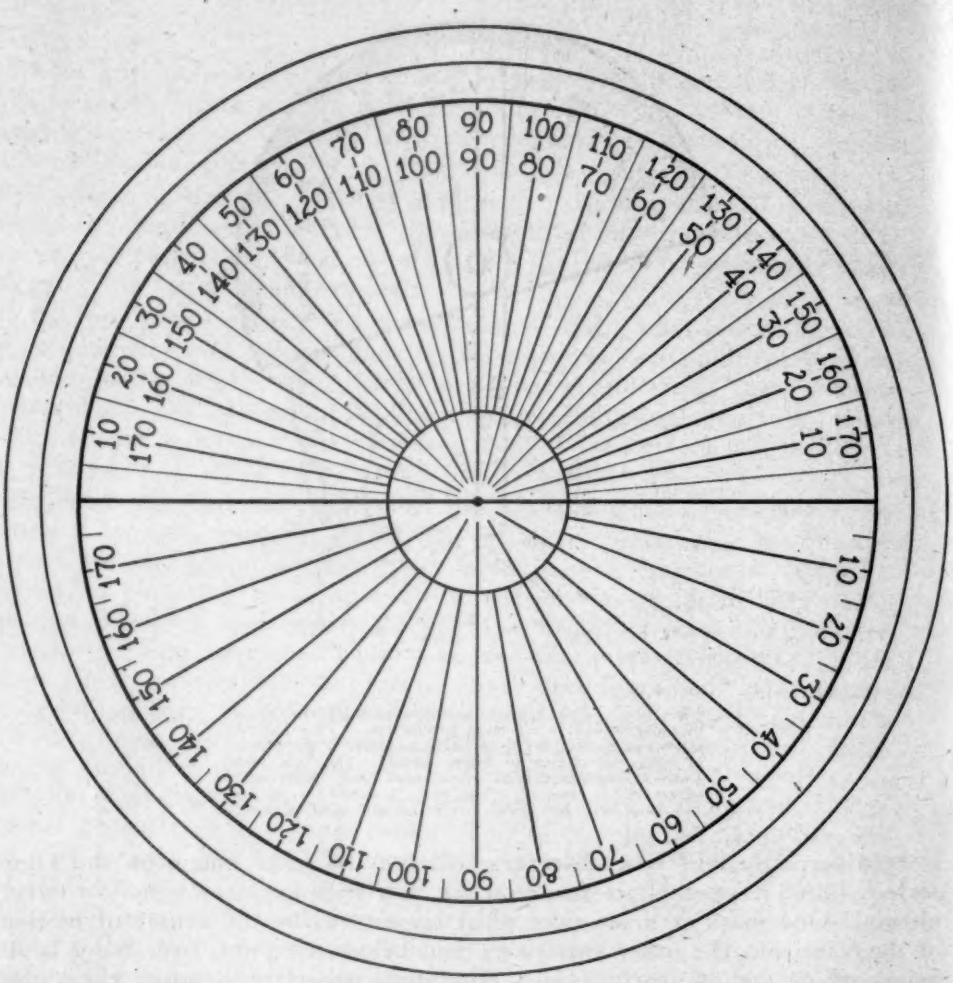

Fig. 2. — A scale of 360 degrees which may be photographed and printed on a transparency for use in the optical goniometer. Either of the two outer circles may be used by the photographer as the outside diameter and will serve as a guide line for cutting out the scale.

a piece of glass similar to that used to protect the scale. The cost of etching the scale on the glass makes it prohibitive, while the transparencies cost about $1.00 each and can be made directly from the illustrations (figs. 2 and 5).

The two transparencies, the lens and two circular glasses can be held together in perfect alignment by the use of aluminum frame. Although the frame holding the larger lens (fig. 3) permits about 2¾ inches (7.0 cm.) diameter of lens to be visible, the frame we used for holding the smaller lens diminished its actual visible size from 2½ inches (6.4 cm.) to 2 inches (5.1 cm.) in diameter.

In clinical use, the optical goniometer is used to read three dots, marked on the skin as previously described. Dots about ¼ to ½ inch (6 to 13 mm.) in diameter are used and renewed with ink, wax pencil or silver nitrate as necessary. The instrument is held as illustrated (fig. 4) at about 3 to 4 feet (91 to 122 cm.) from the patient. Any bright light should be between the lens and the patient, so that it will not be reflected in the lens and make reading difficult.

The advantages of the instrument are its small size, its wide range of use for various joints and the reproducibility of results under conditions

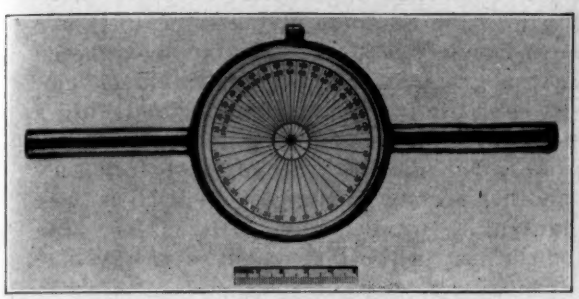

Fig. 3. — The completed optical goniometer using the 3 inch (7.6 cm.) reducing lens. The frame is made of aluminum with two handles. The transparency with the scale is in front of the lens and is covered by a thin piece of glass.

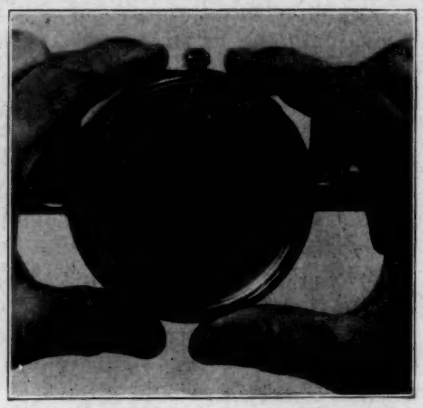

Fig. 4. — The optical goniometer is held with both hands so that it will be steady.

reported in this paper. It might be useful in certain medicolegal problems or evaluation of therapy and disability. It may have nonmedical uses.

The disadvantage is that the observer must focus his vision through the glass on the reduced image apparent at a distance and then accommodate to the scale on the instrument. It is necessary to read the angle which the image forms on the scale; some people do not use an optical instrument easily.

When there is sufficient physical space and more exact readings of angles are desired, one may project a lantern slide reproduction of the 360 degree scale (fig. 2) directly onto the limb being studied. The scale is focused on the landmark dots.

Evaluation of the Device

Tests were devised to show whether a given angle could be read accurately by means of the optical goniometer. The tests were not carried out

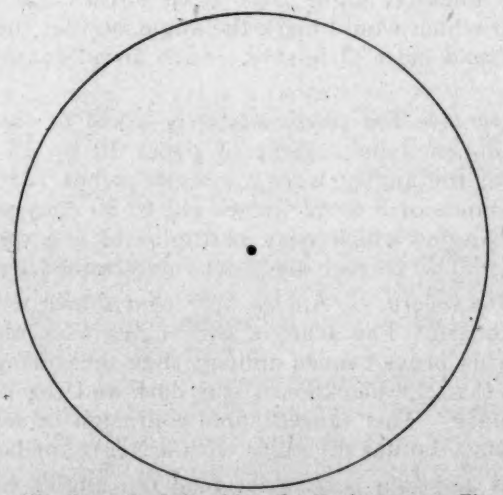

Fig. 5. — A circle with a dot in the center. The outer circle is reduced to the same size as the outside diameter of the scale and printed on a transparency. It is then cut away from the remainder of the film and mounted on the opposite side of the lens from the scale. The purpose of this is to give a second point with which to line up the center point of the scale and the central point of the arm so that they are superimposed and only one dot is seen. This is an effort to eliminate the parallax but it is not essential.

on subjects but were made on angles drawn on paper. Subsequent tests to evaluate the relative merit of the use of this and other devices on patients are under way.

A total of 342 readings of forty-five different angles were made by twenty-nine physicians. As a control group 178 readings of the same forty-five angles were made at the same time and under identical conditions by eighteen physical therapy technicians and stenographers. Not a single person employed in the tests had previously used the optical instrument, and only a few had seen it before. The tests were divided into four groups, and different people were used in each group. No one saw the angles before they read them or heard the results of another person. The angles themselves were not measured until all the observations had been made.

The following instructions for the use of the instrument were given to each observer:

> Hold the instrument in your right hand with the scale toward you (fig. 6).
>
> Close one eye and sight the angle to be measured with the other.
>
> The two center dots of the optical measuring device must be held at the level of, and in an imaginary perpendicular line with, the center dot of the angle.
>
> Keep the lens parallel with the plane of the angle and remember that you may move the device up or down so that it is in the imaginary perpendicular line.
>
> Now take the lower arm of the angle to be measured and sight it so that it coincides with the heavy 180 degree crossline on the scale. The center dots of the device must be superimposed on the center dot of the angle so that there is only one dot visible.
>
> You are now ready to read the upper arm of the angle on the scale. If the upper dot is beyond the 90 degree vertical upright line on the scale read the larger angle, that is, greater than 90 degrees; if less than 90 degrees read the smaller angle.
>
> You may stand as close or as far away as you desire, holding the optical goniometer as near or as far from your eye as you find convenient. It is usually held from 6 to 9 inches (15 to 23 cm.) from the eye.
>
> Read the first angle . . .

No other instructions were given, and no help was given except in the case of some who were confused as to whether to read the smaller or the greater angle.

Some of the difficulty might have been obviated if there had been a movable metal arm which would mark the angle, so that the instrument could bet set down and read more at leisure. Such an adaptation is illustrated in figure 9.

Angles on Paper. — Ten physicians were asked to observe fifteen angles drawn with a lead pencil on a piece of paper 10 by 12 inches (25 by 30 cm.). The arms of the angles were about 10 inches (25 cm.) long. They were read at a distance of 5 to 12 inches (13 to 30 cm.) without any appreciable difficulty. Angles which were multiples of five were read more correctly than others. The correct angle was determined by a protractor.

Angles on a Blackboard. — Angles were next drawn with chalk, guided by a rule, on a blackboard. The arms of the angles were about 12 inches (30 cm.) in length. This proved more difficult than measuring angles on paper, owing to the fact that the blackboard was dark and the scale on the optical goniometer was black. This caused some confusion in seeing the lines and figures and suggests a similar difficulty with a Negro or dark-skinned patient.

Six physicians and four secretaries read ten angles each. Three of the secretaries and one of the physicians read odd angles in multiples of fives and tens only. While the physicians did not express any difficulty, all the stenographers had some uncertainty in reading the angles. One of them was asked to determine the angles on the board with a simple large transparent protractor after she had read them with the goniometer; she could not find

a reasonable angle until the protractor was carefully explained to her. It was obvious that she was not capable of reading angles accurately in any circumstances when the test was made. However, her results were not eliminated.

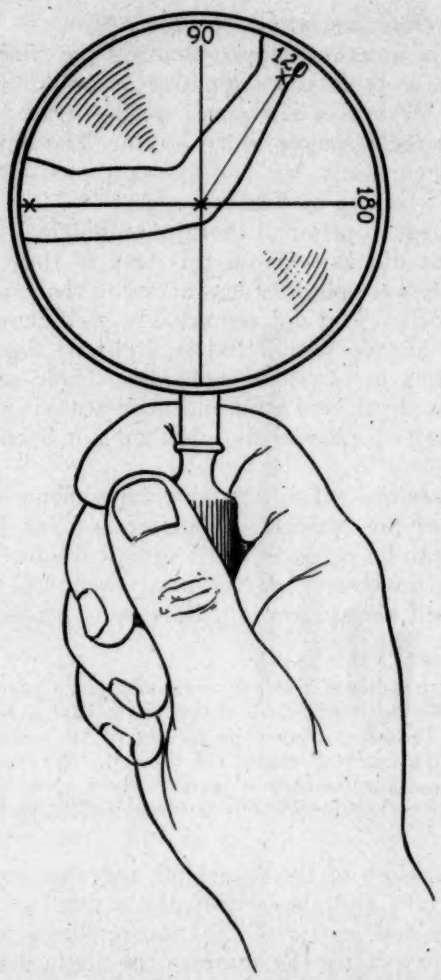

Fig. 6. — The type of instrument employed in this study and the way in which it was held. A 2½ inch (6.4 cm.) reducing lens is shown with the reduced image of the arm as it appears on the scale. Only pertinent angles are shown in this picture although the scale was the same as in figure 2. This instrument is not as good as the one shown in figure 3.

The angles were actually determined independently with a large transparent protractor by two physicians. Their readings varied ±1 degree, and for this reason an error of 1 degree obtained with the optical goniometer or protractor was considered "no error."

Angles Formed by Dots. — Two angles suggested by three dots, each ¼ inch (6 mm.) in diameter, were placed on a sheet of paper 44 by 70 cm. in size. The paper was secured to the wall with thumb tacks. Seven physicians and seven physical therapy technicians each read ten angles. The physicians observed the angles with as much ease and accuracy as they did on the blackboard but not as precisely as on paper.

The technicians, in these circumstances, did better than the clinic secretaries measuring angles on the blackboard. One physical therapy technician

said: "I can't see with this thing. I just guess." Her mean error was ±9.7 degrees, and her errors ranged from —34 degrees to +16 degrees. Her readings were not discarded. The mean error of the other six technicians was ±2.7 degrees.

Angles Formed by Dots in Outline of Man's Arm. — Finally, the optical goniometer was tested in a manner approximating the clinical situation. Angles suggested by three dots of the same size as before were drawn at the sites of the bony landmarks in a silhouette outline traced from the shadow of an arm on a single piece of paper 44 by 70 cm. The upper arm outline on each drawing was held constant, but the forearm was outlined in two positions, one of extension and one of flexion.

Six physicians and seven physical therapy technicians each measured ten angles. The technicians did as well on this test as they did with the dots alone, but the physicians were slightly less accurate than when they observed dots alone. One technician who did remarkably well thought it was due to the fact that she often hunted with (that is, sighted) a gun. In this group were two staff physicians in physical medicine. Their accuracy was about the same as that of two physicians who had been studying physical medicine for two months and the two physicians who had not been in the Section on Physical Medicine.

Interpretation of Results. — The foregoing experiments were devised to test the inherent accuracy of the optical goniometer and not its relative clinical merits. No statement can be made as to its practical value as a result of this study. It would seem, however, that the instrument has some merit.

Lest one lead himself astray, it might be wise to recall Henri Poincaré's[14] admonition:

> It is often said that experiments must be made without a preconceived idea. That is impossible. Not only would it make all experiments barren but that would be attempted which could not be done. Everyone carries in his mind his own conception of the world, of which he cannot so easily rid himself. We must, for instance, use language; and language is made up only of preconceived ideas and cannot be otherwise. Only these are unconscious preconceived ideas, a thousand times more dangerous that the others.

Since the results in each of the four tests revealed comparable performance among the physicians and also within the control group, all the results were gathered together and analyzed. Of the readings made by the physicians, 24.5 per cent were exactly the same as the angle determined by a protractor and 49.5 per cent were in error by ±1 degree, which may be considered as no error. Together, this represents 74 per cent of their readings. Of the control group of women, 10.6 per cent obtained the exact angle and 25.6 per cent made an error of ±1 degree, a total of about 36 per cent. In the frequency distribution of error (fig. 7) there is a cluster with a rapid decline on either side, particularly the positive side, indicating a slight tendency to underestimate the angle. The women, half of whom were college graduates, showed more scatter than the physicians. The range of the physicians' errors was —12 degrees to +13 degrees, while that of the control was —34 degrees to +25 degrees.

Of all the observations by physicians, 99.5 per cent did not exceed an error of ±8 degrees. The control group's readings indicated 73.5 per cent with an error of ±5 degrees or less and 81 per cent with an error not exceeding ±8 degrees. In considering error in terms of ±5 degrees, for example, the total error is in the range of 5 degrees and not 10 degrees. It is apparent that in unpracticed and unskilled hands the optical goniometer is reasonably

14. Poincaré, H.: The Foundations of Science: Science and Hypothesis; the Value of Science; Science and Method (Translated by G. B. Halsted), New York, The Science Press, 1929.

accurate. In skilled but unpracticed hands its accuracy is good. This is illustrated in figure 8.

The mean error of 342 readings by physicians was —0.66 and the standard error of the mean was 0.14, which is to say that their average was a slightly negative figure but consistently negative. The standard deviation or variability of the observations themselves was 2.53; in other words, ±2.5 degrees of the readings accounted for 68 per cent of the total observations.

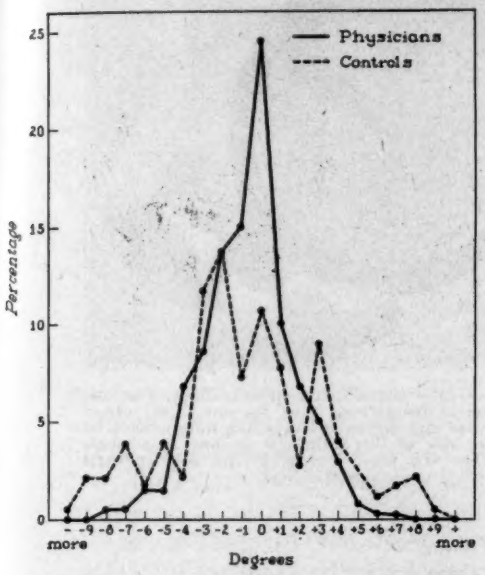

Fig. 7. — Frequency distribution showing central cluster and scatter of readings by physicians and controls. Degrees are recorded in errors plus or minus.

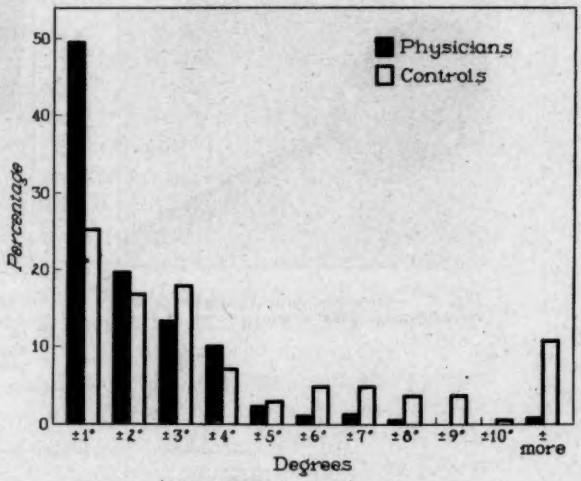

Fig. 8. — Error of readings in degrees without regard for sign by physicians and controls. Note the more rapid decline in error from ±1 degree in the case of the physicians.

Two times the standard deviation reveals that 95 per cent of the physicians read within ±5 degrees, or an error of 5 degrees without regard to the sign. The probable error of the physicians' readings indicated that there was a 50 per cent chance of readings within ±1.7 degrees of the true angle.

The readings by the control group showed a random sampling scatter apparently without bias. The technicians' mean error was negligible, being —0.29 ±0.37. The standard deviation was 4.97, which was nearly twice that of the physicians. There was a 95 per cent chance that the controls would read an angle within ±10 degrees.

Comment

An improved optical goniometer which eliminates most of the disadvantages previously mentioned is illustrated in figure 9. The system of lenses and scale is identical with that previously described. To hold the device in a sturdy mounting, with a rotating circular marking arm, Mr. Dana Rogers and Mr. I. A. Quehl, of the Mayo Clinic Instrument Shop, perfected and machined the instrument shown in figure 9. The device is held with one hand (fig. 10) and, after the angle to be measured has been sighted in the manner described previously, the marking arm is rotated until it coincides with the upright arm of the angle. The instrument can then be read at one's leisure. Thus one does not have to read the angle at a moment's glance.

Figure 11 shows the constructional details of the mechanism. The rotating arm does not come in contact with the glass.

This instrument is more satisfactory than those described earlier in the paper. Unfortunately, the expense of producing the device in small quantities is relatively large.

When serial measurements are made for the purpose of comparison and true precision is not demanded, the most reasonably accurate and simple

Fig. 9. — Improved optical goniometer with rotating arm. This is constructed of brass.

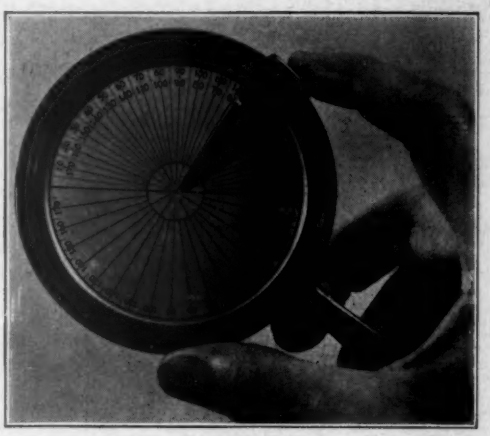

Fig. 10. — The same instrument as in figure 9 in use. The point of the rotating arm, the dot at the center of the scale and the small dot on the transparency on the other side of the device are in line at a single point. The arm moves freely but will hold an angle unless moved.

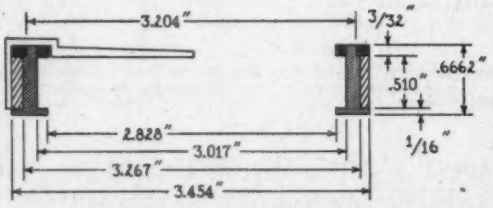

Fig. 11. — Machinist's drawing showing details of device which holds the lenses.

method for the task should be chosen. This is particularly true in the field of physical medicine, in which the collection of accurate data is so urgently needed. It serves no purpose whatsoever to argue that refinement of measuring instruments is unnecessary so long as methods are now employed the results of which cannot be reproduced from one observer to another. Since the clinician expects a quantative expression of the value of physical therapy, the physiatrist should give due prominence to the deficiencies of these measurements and at the same time lay down stringent rules for the guidance of the observer. It is imperative that the technics of measurement be divorced, so far as it is possible, from the psychic factors which influence the observer and the observed. The inadvertent bias (the unconscious preconceived idea) should be removed.

Many people have long suspected that readings with an ordinary goniometer may be quite erroneous. An occasional author has written that readings are made not only for the physician but also for the psychologic effect on the patient. Regardless of the truth of this statement, it implies a desire for improvement. Owing to the fact that the two arms of the goniometer can be moved on the patient's arm ever so slightly to get a better range of

(*Continued on page 723*)

ULTRAVIOLET AIR DISINFECTION

WILLIAM T. ANDERSON, JR., Ph.D.

NEWARK, N. J.

The occurrence of colds, influenza and other epidemic diseases are infrequent during the summer months when buildings, buses and subway cars are freely ventilated by out-of-doors air. The public health officers and members of the medical profession have recognized that this results in part from the high sanitary quality of out-of-doors air, which is practically free from pathogens.

During the winter months the conservation of heat and the avoidance of drafts restrict greatly the extent of fresh air venilation. Numerous tests have confirmed that at such times pathogens are frequently present in unsafe concentrations in the air of occupied rooms.

Numerous animal experiments conducted under strictly controlled conditions have established the transmission of infection by the air-borne route. Thus, influenza types A and B have been transmitted to mice and ferrets.[1] Tuberculosis has been transmitted to rabbits.[2] Poliomyelitis has been transmitted to monkeys.[3] A few laboratory observed cross-infections between humans have been reported and are very suggestive that air-borne organisms were responsible. Among these mention should be made of a laboratory outbreak of Q fever caused by Rickettsia burnetti[4] and an institutional outbreak of pneumonitis.[5]

The relative importance of dust, droplets or droplet nuclei in the spread of disease of bacterial and virus origin is not known. Dust in hospital wards and army barracks has been shown[6] to become greatly contaminated with pathogens associated with streptococcic infections of the respiratory tract. Housekeeping activities such as floor sweeping, bedmaking and dressing have resulted in contamination of the air in the whole environment, which has provided many opportunities for the spread of infectious disease. Prevention of air-borne dust may effectively be accomplished by oiling of floors, bedding and other textiles. Experience in army barracks indicated that this can effect a significant reduction in the incidence of respiratory infections of streptococcal origin.

Aside from dust air-borne micro-organisms, as a result of the respiratory process, talking, coughing and sneezing, there is a continual interchange between the air and the persons in a room whereby bacteria may be transferred from one person to another. Only a few of these bacteria and viruses are pathogenic, but if a pathogen is transferred to a new host an infection may result. These droplet and droplet nuclei air-borne micro-organisms frequently remain air borne for many hours. The oil treatment on floors, bedding, etc., can effectively immobilize these only after they have settled.

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1. Wells, W. F., and Brown, H. W.: Recovery of Influenza Virus Suspended in Air and Its Destruction by Ultraviolet Irradiation, Am. J. Hygiene 24:407, 1936. Andrews, C. H., and Glover, R. E.: Spread of Infection from the Respiratory Tract of the Ferret: I. Transmission of Influenza A Virus, Brit. J. Path. 22:91, 1941. Loosli, C. G.; Robertson, C. H., and Puck, T. T.: The Production of Experimental Influenza in Mice by Inhalation of Atmospheres Containing Influenza Virus Dispersed as Fine Droplets, J. Infectious Dis. 72:142, 1943.
2. Lurie, M. B.: Experimental Air-borne Tuberculosis and Its Control, Am. Rev. Tuber. 55:124, 1947.
3. Faber, H. K.: Silverberg, R. J., and Dong, L.: Poliomyelitis in the Cynomolgus Monkey. III. Infection by Inhalation of Droplet Nuclei and the Nasopharyngeal Portal of Entry, with a Note on This Mode of Infection in Rhesus, J. Exper. Med. 80:39, 1944.
4. Commission on Acute Respiratory Diseases: A Laboratory Outbreak of Q Fever Caused by the Balkan Grippe Strain of Rickettsia Burnetti, Am. J. Hygiene 44:123, 1946.
5. Hornibrook, J. W., and Nelson, K. R.: Institutional Outbreak of Pneumonitis, Pub. Health Reports 55:1936, 1940.
6. Dust and Its Control as a Means of Disinfection of Air. Commission on Air-borne Infection, Army Epidemiological Board 37:353, 1947.

Sanitary Ventilation

Dilution of the air in a room by sufficient fresh, pure air to reduce the concentration of air-borne organisms to safe levels appears to be accomplished during the summer months when windows are freely opened and drafts are not objectionable, for at such time the incidence of epidemic diseases is at a minimum. When doors and windows are closed, the degree of sanitary ventilation required is the reduction in hazard of breathing micro-organisms released into the air of the room by some infector.

During the winter months buildings are usually insufficiently ventilated. Air-conditioned buildings are not only insufficiently ventilated at all times, but air-circulating equipment recirculates the bacteria because only a small part of the air volume is replaced each time by pure air. The sanitary codes in some states require only that school rooms should have not less than 30 cubic feet of pure air per person per minute. For the ordinary school room with 30 pupils this minimum amounts to only three to four complete air changes per hour. This is adequate to maintain the oxygen balance but absolutely insufficient for sanitary ventilation. Tests made during the past ten years in which I have cooperated have suggested that a minimum of 500 cubic feet of pure air is required per person per minute, or sixty to seventy-five complete air changes per hour for the typical room, if the epidemic hazard by air-borne infection is to be eliminated. In enclosed space of high occupancy such as reception rooms, wards, clinics and the like, ventilation rates in excess of one hundred air changes per hour may be required for adequate sanitation. Ventilations by means of pure out-of-doors air at these rates are not practical.

The measurement of air pollution requires the services of an experienced bacteriologist. The methods employed rarely apprehend more than a fraction of the air-borne organisms but are sufficient to indicate their relative abundance. Petri dishes may be employed to fix droppings, or a centrifuge method such as that described and devised by Wells [7] may be used to collect samples of air-borne organisms. Typical measurements made by centrifuge method are given in table 1.

TABLE 1. — *Relative Number of Bacteria in Air (Blood Agar at 37 C.)*

Location	Condition	Colonies/10 Cu. Ft. Air*
City	Out of doors, summer	30
City	Out of doors, winter	10
Schoolroom	Old building, winter, 38 pupils	250
Schoolroom	New building, winter, 25 pupils	150
Children's clinic	Old building, winter, 25 persons	800
Operating room	Hospital, winter, 8 persons	80
Doctor's office	Natural ventilation, 5 persons per hour, 4 hours	300
Doctor's reception room	Natural ventilation, 12 persons per hour	400
Hospital ward	Old building, winter, 16 children	550

* Values rounded to the nearest multiple of 10.

The existence of air-borne micro-organisms is now well established. The first report of the Subcommittee for the Evaluation of Methods to Control Air-borne Infections, of the Committee on Research and Standards of the American Public Health Association, was presented on Nov. 14, 1946, and published in January, 1947.[8] It includes a lengthy bibliography of recent papers on the measurement and evaluation of air-borne bacteria and viruses.

7. Wells, W. F.: Apparatus for Study of the Bacterial Behavior of Air, Am. J. Pub. Health 23:8, 1933; Air-borne Infection: II. Droplets and Droplet Nuclei, Am. J. Hygiene 20:611, 1934.

8. Committee on Research and Standards, American Public Health Association: The Present Status of the Control of Air-borne Infections, Am. J. Pub. Health, 37:13, 1947.

Equivalent Sanitary Ventilation

The objectives of sanitary ventilation may be attained by either an adequate number of pure air changes or a proportionate destruction of the air-borne bacteria by some suitable means. The latter method may be considered to be an equivalent sanitary ventilation.

Wells[9] has defined the equivalent of one complete air change by pure air as the "lethe." Provided a room is unoccupied, so that there is no new source of infection, one complete air change, or the sanitary equivalent of one complete air change, will reduce the initial air, carbon dioxide, dust, air-borne bacteria and odor to 36.8 per cent of the original. This is a reduction by 63.2 per cent in the bacterial content of the air of the room. A second complete air change will attain a disinfection of 86.5 per cent. Repeated air changes will reduce the bacterial content to a very low value, but a strictly sterile condition can never be attained.

This rate of reduction applies only to an unoccupied room. An occupied room contains sources for reinfection of the air, with the result that a condition of dynamic equilibrium always exists between removal and reinfection. Sanitary ventilation must maintain this equilibrium concentration below the hazard of epidemic.

Because it is frequently impractical to provide sanitary ventilation by actual air changes, equivalent sanitary ventilation must be employed and must provide not less than 500 cubic feet lethes of pure air per minute per person, or 30,000 cubic foot lethes of pure air per hour per person.

Ultraviolet air disinfection may provide equivalent sanitary ventilation. One lethe of disinfection results from the uniform radiation of wavelength 2,537 angstroms at an intensity of 35×10^{-6} watt hour per square foot in a room in which the relative humidity is below 50 per cent. Since the moisture in the air of a room during the colder months condenses mostly upon the colder walls and windows, the relative humidity is usually below 50 per cent. However, if the humidity of higher than 50 per cent, a corresponding greater energy value for the lethe must be employed, since water vapor in the air protects the bacteria from the destructive action of the ultraviolet radiations.[10]

The Safe Application of Ultraviolet Radiations

Ultraviolet radiations at wavelengths 2,537Å may be used with complete safety for the occupants of a room if a few simple precautions are taken. Radiations at this wavelength which are lethal to bacteria will also produce skin erythema and eye discomfort. Observation which I made on human subjects who were exposed to various measured intensities of 2,537 Å radiation for two hour periods indicated that for a twenty-four hour period, such as might be experienced in a ward or nursery, the intensity of ultraviolet radiation at this wavelength should average at the skin and eye level less than 0.0002 watt per square foot — that is, less than 0.2 microwatts per square centimeter. This confirms the advice of the Council on Physical Medicine, American Medical Association,[11] that the maximum safe intensity for twenty-four hour period is 0.1 microwatt per square centimeter of 2,537 Å radiation. If the period of exposure be less than twenty-four hours, the intensity may be correspondingly higher, for the reciprocity law appears to apply.

The radiation intensity required for ultraviolet air disinfection is very considerably in excess of these tolerance limits. This necessitates that

9. Wells, W. F.: Bactericidal Irradiation of Air, J. Franklin Inst. 229:347, 1940; Radiant Disinfection of Air, Arch. Phys. Therapy 23:143, 1942.
10. Whisler, B. A.: The Efficacy of Ultraviolet Light Sources in Killing Bacteria Suspended in Air, Iowa State College J. Sc. 14:215, 1940.
11. Acceptance of Ultraviolet Lamps for Disinfection Purposes, Official Report of the Council on Physical Medicine of the American Medical Association, J. A. M. A. 118:298, 1942.

lamps used for such disinfection be located and the rays projected in such a manner that the occupants of the room may at no time nor in any position receive any direct irradiation and that reflected radiations be below the tolerance limits. The latter requirements necessitate that wall and ceiling finishes and appurtenances of the room have low reflectivity for ultraviolet at 2,537 Å, preferably lower than 10 per cent. In particular, water paints and wall papers usually have very excellent reflectivity for ultraviolet at 2,537 Å and must not be used in conjunction with lamps used for air disinfection. I have made measurements on the reflectivity of many substances and recommend those given in table 2.

TABLE 2. — *Materials of Low Reflectivity for Use with Bactericidal Lamps*

Material	Condition	Per Cent Reflectivity
Glass	Brick, mirrors, lighting globes	4-6
Enamels	Baked, any color and white	5-10
Oil paints	Lead, any color and white	5-10
Oil paints	Zinc, any color and white	3-6

It is important that personnel in institutions employing ultraviolet air disinfection be cautioned to wear protection goggles when dusting and cleaning lamps. If it should be necessary to extinguish the lamps, this should be done for as brief a period as possible, since their protective value ceases the moment they are extinguished.

Ozone gas is not produced by the radiations at 2,537 Å which are employed for air disinfection. Ozone should be considered, however, because some ultraviolet lamps do produce radiations of wavelength much shorter than 2,537 Å and these convert some of the oxygen of the air into ozone gas. Very small amounts of ozone gas are not objectionable because such amounts are a common constituent of the normal atmosphere. When ozone is present in concentration better than 0.01 part per million parts of air, it may be detected by its characteristic odor. In concentrations better than 0.1 part per million of air, ozone is objectionable and irritating to the mucous membrane of the nose and throat. Experience has indicated that lamps used for air disinfection should not produce ozone concentrations in excess of 0.01 part per million parts of air in a closed room. Compliance with this requirement may be readily checked by the nose test.

The Application of Ultraviolet Air Disinfection

Two methods have been developed for the application of ultraviolet air disinfection. They are (*A*) the upper air irradiation method and (*B*) the air duct irradiation method.

In method *A* the lamps project their radiations into the air in the upper unoccupied portion of the room only. This air is maintained at a high degree of sterility. The air below the 7 foot level receives only the very weak and ineffective ultraviolet rays reflected from the ceiling and depends for disinfection upon dilution with sterilized air from the upper portion of the room by a process of natural air interchange.

In method *B* the lamps are installed within the air duct of the air-circulating system and provide a supply of near-sterile air for the room. Since the air-borne bacteria are exposed by this method for very brief periods,

The Application of Ultraviolet Air Disinfection

higher intensities of ultraviolet radiation, and therefore more lamps, are required for method *B* than for method *A*.

Both methods depend ultimately upon the rate of natural air interchange in the room for satisfactory dilution of the bacterial air content at the breathing levels. This interchange of air is assisted by the natural air drafts, temperature gradients and motion of occupants in the room.

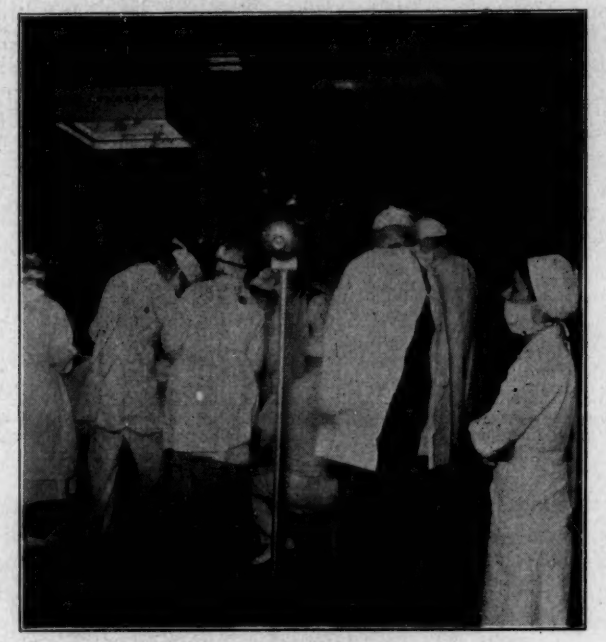

Fig. 1. — Operating room, Deaconess Hospital, Boston

I attempted in 1940 to measure the air interchange between the upper and lower air strata in closed unoccupied rooms by the ozone method. Conditions were very similar to those encountered in method *A*. The ozone was produced by ozone generators consisting of thin wall quartz mercury dis-

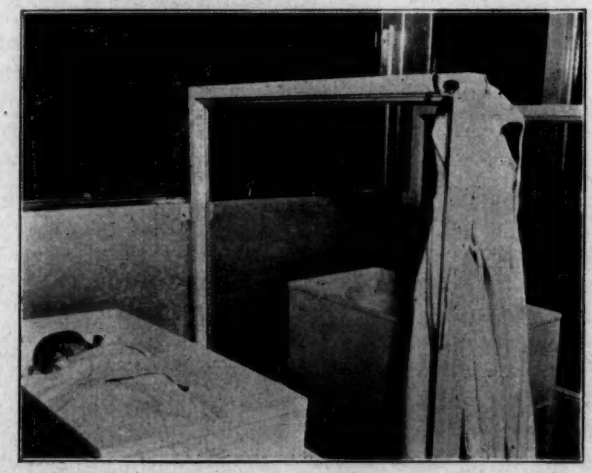

Fig. 2. — Installation of SAFE-T-AIRE fixture at St. James Hospital, Newark, N. J.

charge tubes, mounted 7 feet from the floor. Only the air in the upper portion of the rooms was exposed to the ozone producing radiations (1,849 and

1,900 Å); hence any ozone found in the lower portion of the rooms could result only from air interchange.

The relative concentrations of ozone in the two air layers were determined by simultaneously exposing prepared starch-iodide papers in the layers, protecting them from radiations and timing with a stopwatch to one-fifth of a second the time required to match the adjacent blue comparison standard. By starting the experiments with zero detectable ozone and timing until easily measurable quantities of ozone were in both zones, it was possible to obtain some measure of the rate of air interchange between the two air zones. The results were calculated to approximate rates of recirculation per hour and are given in table 3.

TABLE 3. — *Air Recirculation in Rooms by Ozone Method*

Type of Room	Volume in Cubic Feet	Ceiling Height in Feet	Approx. Rate of Recirculation Per Hour
Clinic	36,000	20	110
Operating	16,000	40	130
School	18,000	15	70
Office	7,800	12	60

NOTE: All doors and windows were closed. The writer was the only occupant of the rooms. Preliminary tests were made in laboratory, and room tests required only a few minutes after the tubes had been installed.

The results were interpreted to indicate that there was sufficient natural interchange between the upper and lower air levels in rooms to make air disinfection by means of dilution with sterile air practical. Actual measurement of air pollution in rooms provided with ultraviolet air disinfection have confirmed it.

Wells[12] tested air interchange in 1945, using a bactericidal method with lamps at a height of 7 feet provided with visored low angle beam and an average intensity of 0.02 watt per square foot radiation at 2,537 Å. He reported 120 to 220 equivalent overturns per hour between the upper and lower layers of air, which are just about twice the values indicated by the ozone tests.

Use of a fan, heated radiators, opening of doors and motion within the room will materially assist air recirculation and provide the mixing that is so necessary for practical application of ultraviolet air disinfection. Even without these, the tests indicate that circulation is usually adequate. Thousands of practical installations which do not employ fans or any other special means for moving air are now in daily operation. Many of these are in hospitals where careful check has been maintained on bacterial content of the air. It has been found that the bacteria in the breathing area are satisfactorily maintained at a low concentration.

The radiation engineering involved in the installation of ultraviolet air disinfection have been described in detail in another paper.[13] Each method of application has advantages and disadvantages. The upper air irradiation method (*A*) is functioning right in the room with the occupants, requires consideration for their safety, depends upon the efficiency of natural air recirculation and becomes less effective as the ceiling becomes lower and the number of occupants increase. The air duct method (*B*) requires more lamps for the same air volume because the bacteria are exposed for such a short time to the killing radiations. Lamps are less efficient unless protected by shields because the air draft cools them. Near-sterile air can be provided

12. Wells, W. F.: Circulation in Sanitary Ventilation by Bactericidal Irradiation of Air, J. Franklin Inst. 240:379, 1945.
13. Anderson, W. T., Jr.: Ultraviolet Sanitary Ventilation, Heating & Ventilating 44:63, 1947; Prevention of Air-borne Infection: Its Application to Hospitals, Hosp. Management 63:76, 1947.

for the room, but the lamps in the duct have no disinfecting action upon the air after it has left the duct. There is not any necessity to consider the safety of the occupants of the room and to protect them from stray radiations. The ozone factor is present for both systems, and lamps productive of low concentrations of ozone should be selected.

A number of special applications have developed in the institution. They are (1) elimination of air-borne infection in the operating room; (2) prevention of cross infection in contagious disease and pediatric wards; (3) disinfection of vacated private rooms; (4) air sanitation in pharmaceutical and vaccine laboratories; (5) use in locations where air disinfection is a useful adjuvant to aseptic technics.

The American Public Health Association has recorded approval[8] for the use of ultraviolet air disinfection for the first and second special applications, provided there exists potentially a significant incidence of cross infection or serious risk to patients. These are two applications in places where there have been amassed conclusive evidence of the need for air disinfection and where ultraviolet radiations have produced such spectacular results. The committee of the Association believes that there is need for more precise knowledge regarding the epidemiology of acute infectious disease in crowded populations before the extent of application of control of air-borne micro-organisms may be defined.

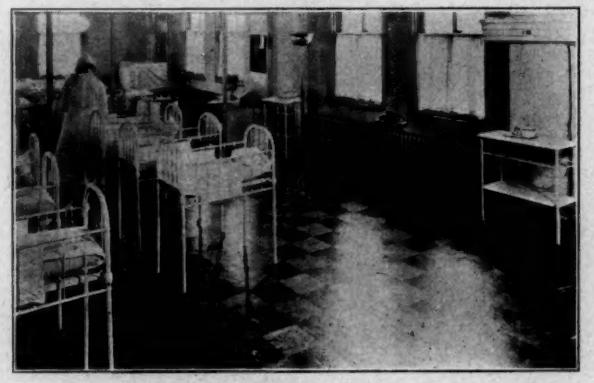

Fig. 3. — Installation of SAFE-T-AIRE fixtures in West Suburban Hospital, Oak Park, Ill.

In certain of these applications, such as the hospital operating room, direct irradiation with the ultraviolet rays is necessary to produce adequately sanitary air. The air at the incision must be irradiated, and this necessitates that the surgeon and his staff be directly exposed to the rays. Eyes must be protected by suitable goggles and exposed skin must be shielded by masks or visor caps. Except for abdominal operations, it is advisable to mount one lamp directly on the operating table lamp.[14]

For the disinfection of vacated private rooms in a hospital a portable ultraviolet lamp which radiates in all directions and which may include a fan to improve air circulation has been used successfully by many institutions for the preparation of a room for a new patient. Since this application is employed when a room is completely unoccupied, lamps with very high ultraviolet output may be used.

Institutions and manufacturers have combined in many experiments which are amassing a wealth of observations which may ultimately establish

14. Kraissl, C. J.; Cimiotti, J. G., and Meleney, F. L.: Considerations in the Use of Ultraviolet Radiation n Operatng Rooms, Ann. Surg. 111:161, 1940.

the limitations of air disinfection in the control of infection. These experiments must involve either a large number of potential infectees or a time period of several years in order that statistical data be valid. Reports on these experiments are appearing frequently in the medical journals. Aside from the statistical allowable data in such reports, side remarks may serve as a possible indication of future trends. Thus in one very recent report[15] there appeared an otherwise irrelevant sentence which read, "There was an obvious decrease in incidence of respiratory disease among adult attendants."

Summary

Experiments and experiences have indicated that air disinfection may be satisfactorily accomplished and maintained in all ordinary installations by means of ultraviolet radiations. Its application for the elimination of air-borne infection in operating rooms and for the prevention of cross infection in contagious disease and pediatric wards has been approved by the Public Health Association after a careful study of all evidence. There are many reported indications that ultraviolet air disinfection may be beneficial in other applications, such as barracks, schools, offices and places of public congregation.

Present experience indicates that the pure air requirements per person are of the order of 30,000 cubic feet of pure air per hour. This rate of sanitary ventilation may usually be obtained by ultraviolet air disinfection.

15. Higgons, R. A., and Hyde, Gertrude M.: Effect of Ultraviolet Air Sterilization Upon Incidence of Respiratory Infections in a Children's Institution, New York State J. Med. 47:707, 1947.

REFRIGERATION ANESTHESIA *

A Review

RICHARD CARTER, A.B.

and

FRED B. MOOR, M.D.

LOS ANGELES

Ice and cold applications as therapeutic agents have been used in the practice of medicine from time immemorial. However, recent interest in therapeutics has been stimulated chiefly by the independent work of both Temple Fay and Frederick M. Allen. In 1936, Temple Fay, having become interested in the peculiar habit of metastatic carcinoma to appear in the warmer body areas, undertook to study the effect of cold on neoplastic tissue.[1] In the subsequent application of this principle, Fay and his coworkers used cold much more thoroughly than previously thought possible. In certain patients a state of artificial hibernation was induced wherein the general body temperature was lowered 10 to 15 F. and maintained at those levels for days at a time. In others, local temperatures of 40 to 50 F. were continued

* This thesis won the first Birtcher Scholarship award, in 1946, at the College of Medical Evangelists. Mr. Carter, at the time, was third year medical student.

1. Fay, Temple, and Henny, G.: Correlation of Body Segmental Temperature and Its Relation to the Location of Carcinomatous Metastasis. Clinical Observations and Response to Methods of Refrigeration, Surg., Gynec. & Obst. 66:512 (Feb.) 1938.

for as long as five months.[2] Despite the favorable inhibition and even regression of neoplastic tissue as was noted by these investigators, the most significant part of the work was not this action of cold on neoplastic tissue but the demonstration that cold could be vigorously applied for prolonged periods without any evidence of damage to living tissue. Repeated pathologic examinations of tissue by these and other observers [3] showed an unimpaired cellular structure in normal tissue and cellular and nuclear disintegration in neoplastic tissue.

Working independently, Frederick M. Allen studied temperature changes in relation to gangrene of the extremities, especially in diabetic patients. Through animal experimentation, Allen soon demonstrated that ischemic necrosis of an animal's extremity could be greatly delayed by simultaneous use of local temperatures just above freezing. Allen's essential findings — the product of hundreds of experiments on rats, rabbits, cats and dogs over a ten year period — was that the modification of local metabolism by temperature enormously influenced the survival, from a few hours or even minutes at elevated temperatures to fifty-four hours at a temperature near freezing.[4] In addition, it was noted that blood did not clot in the vessels during or after the procedure; the vessels themselves were not injured; peripheral nerve paralyses were prevented or delayed in onset, and anesthesia of the limb took place in from one to three hours. This anesthesia was complete and allowed painless amputation of the extremity to be performed without shock. No evidence of damage to the remaining tissue below the tourniquet was observed, and primary healing was the rule. From these studies Allen, in 1941, was the first to demonstrate clinically that a tourniquet could be applied to a limb and that the part distal to the tourniquet could be enveloped in ice to produce after a suitable period of time surgical anesthesia.

Refrigeration anesthesia has a sound experimental basis. During the past twelve years, extensive investigation has been carried out on the effects of temperature and its influence on the survival of damaged tissue. Blalock[5] traumatized the extremities of 54 large animals and exposed the limbs of 29 animals to local cold and those of 25 to heat. He found the survival period with cold to be twice that with heat. Blalock and Duncan[6] carried out experiments on crush injuries and trauma to large masses of muscle in medium-sized animals. In 7 of the experiments, ice was applied simultaneously with the destructive pressure. Tissue swelling of the extremity, changes in blood pressure and hematocrit and urinary abnormalities were minimal, indicating little or no evidence of shock or toxic absorption. They concluded that ill effects can be avoided by refrigerating the part during the period of anoxia and ischemia. If the application of a tourniquet is necessary, cooling of the part distal to it greatly reduces the chances of development of shock after release of the constricting tourniquet.

Wakim and Gatch[7] noted the effects of various external temperatures in contact with control and experimentally shocked animals. Abnormally

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2. Smith, L. E., and Fay, Temple: Observations on Human Beings with Cancer, Maintained at Reduced Temperatures of 75-90 Degrees Fahrenheit, Am. J. Clin. Path. **10**:1 (Jan.) 1940.

3. Fay, Temple, and McGravey, A.: Pain Relief by Local and Generalized Refrigeration, Dis. Nerv. System **1**:312 (Oct.) 1940. Whittemore, W. L.; Lisa, J. R., and Sauer, P. K.: Human Refrigeration, New York State J. Med. **40**:1563 (Nov. 1) 1940. Sano, M. E., and Smith, L. W.: A Critical Histopathologic Study, J. Lab. & Clin. Med. **26**:443 (Dec.) 1940.

4. Allen, F. M.: Surgical Considerations of Temperature in Ligated Limbs, Am. J. Surg. **45**:459 (Sept.) 1939; Local Asphyxia and Temperature Changes in Relation to Gangrene and Other Surgical Problems, Tr. A. Am. Physicians **52**:189, 1937; Experiments Concerning Ligation and Refrigeration in Relation to Local Intoxication and Infection, Surg., Gynec. & Obst. **68**:1047 (June) 1939; Reduced Temperatures in Surgery: I. Surgery of Limbs, Am. J. Surg. **52**:225 (May) 1941.

5. Blalock, A.: A Comparison of the Effects of Heat and Those of Cold in the Prevention and Treatment of Experimental Traumatic Shock, Surgery **11**:356 (Mar.) 1942.

6. Blalock, A., and Duncan, G. W.: Traumatic Shock—A Consideration of Several Types of Injuries, Surg., Gynec. & Obst. **75**:401 (Oct.) 1942.

7. Wakim, K. G., and Gatch, W. D.: The Effect of External Temperature on Shock, J. A. M. A. **121**:903 (Mar. 20) 1943.

low or abnormally high temperatures proved to be deleterious to the life of animals in shock. They concluded that an external temperature in the neighborhood of that of the mammalian body seems to be optimal for the survival of shocked animals. Clinical experience with peripheral vascular disease indicates the beneficial effects of cooling traumatized or gangrenous extremities. It is now generally accepted that the cold extremities of the patient in shock are that way because of a compensatory vasoconstriction, so that the reduced blood volume may be available for vital centers. Excessive heat will do harm to the shocked organism in several ways, as Wakim and Gatch pointed out. It will produce a widespread superficial vasodilatation and distribution of blood to nonessential parts, thus counteracting the protective natural reflexes that brought about peripheral vasoconstriction in the skin and neighboring tissues which are not so vitally in need of blood during the emergency of shock. Excessive heat will increase the metabolism and the oxygen requirement of tissues. In the presence of an already existing anoxemia, overheating necessitates the utilization of more oxygen and hence leads to a more severe anoxemia, which will increase capillary damage and capillary permeability and may terminate fatally. Excessive heat is likely to increase perspiration and consequently promote dehydration, which aggravates the hemoconcentration and oligemia already present. And hot water bottles applied to semicomatose patients often produce serious burns. Wakim and Gatch have rendered valuable service in adding experimental and theoretical warnings against the practice of overheating patients in shock.

In 1942 Lahz[8] noted that optimum temperatures for exsanguinated tissue is much lower than for normal tissue and that the former can be severely damaged by heating agents. Freeman[9] in a recent paper on the influence of temperature on the development of gangrene in peripheral vascular disease, concluded that the optimum temperature for an extremity which is the seat of occlusive vascular disease is between 30 and 34 C. Cold produces vasospasm; heat increases the metabolic demands of the tissues beyond their circulatory capacity and may precipitate gangrene. Starr[10] in 1934 also recognized this danger. Sir Thomas Lewis'[11] classic work demonstrated that tissues remain viable well below freezing.

As an outgrowth of these experimental studies, Frederick Allen interested a group of surgeons at the New York City Hospital to apply refrigeration clinically in cases of peripheral vascular disease requiring amputation because of gangrene. Priority in the use of cold as an anesthetic for amputations is generally accredited to this group, and the first such amputation with tourniquet and ice pack was performed on Jan. 12, 1941.[12]

The Use of Cold as Preoperative Anesthetic

The various terms designating the use of cold as an anesthetic are "hypothermic anesthesia," "freezing," "frozen sleep," "hibernation," "crymoanesthesia" and "refrigeration anesthesia." Refrigeration anesthesia means ice water anesthesia.[13]

The principle of refrigeration anesthesia is simple and physiologic and is best explained in Allen's own words:[14]

8. Lahz, R. S.: Notes on the Use of the Tourniquet, M. J. Australia, 1:465 (Apr. 18) 1942.
9. Freeman, N. E.: Influence of Temperature on the Development of Gangrene in Peripheral Vascular Disease, Arch. Surg. 40:326 (Feb.) 1940.
10. Starr, I.: On the Use of Heat, Desiccation and Oxygen in the Local Treatment of Advanced Peripheral Vascular Diseases, Am. J. M. Sc. 187:498 (Apr.) 1934.
11. Lewis, T.: Observations on Some Normal and Injurious Effects of Cold Upon the Skin and Underlying Tissues: I. Reactions to Cold and Injury of Normal Skin, Brit. M. J. 2:795 (Dec. 6) 1941.
12. Crossman, L. W.; Ruggiero, W. F.; Hurley, V., and Allen, F. M.: Reduced Temperatures in Surgery: II. Amputations for Peripheral Vascular Disease, Arch. Surg. 44:139 (Jan.) 1942.
13. Crossman, L. W.; Allen, F. M.; Hurley, V.; Ruggiero, W., and Warden, C. E.: Refrigeration Anesthesia, Anesth. & Analg. 21:241 (Sept.-Oct.) 1942.
14. Allen, F. M.: Refrigeration Anesthesia for Limb Operations, Anesthesiology 4:12 (Jan.) 1943.

Basically, refrigeration anesthesia reduces metabolism to a point which is just compatible with tissue viability. Thus, in a leg with advanced arteriosclerosis, metabolism can be reduced to a level where the existing circulation is adequate for the needs of the tissues. . . . Nerve impulses are abolished. Also, one of the fundamental properties of protoplasm, which is irritability, is arrested by cold. Therefore, this method differs fundamentally from all previously known anesthetics in producing anesthesia not only of nerves but of protoplasm. . . . Under refrigeration, shock is nonexistent, and the duration and degree of tissue trauma immaterial.

From his experimental work, Allen was convinced that refrigeration prolongs the viability of poorly oxygenated tissues. In operative cases, pain is markedly reduced by the action of cold; edema is lessened, owing to the vasoconstriction which minimizes transudation of tissue fluids.[15] The incidence of thrombosis and embolism is reduced; necrosis is prevented; a marked inhibition of bacterial growth occurs with a decrease in the incidence of infection, and healing is slightly delayed.[15]

Now, how is anesthesia produced by refrigeration? Refrigeration is a chilling of tissues; it is not freezing. Freezing damages tissues, sometimes irreparably. Frostbite is a clinical example of freezing. Water freezes at 0 C. (32 F.). Blood and tissues freeze at a slightly lower level. In refrigeration anesthesia the limb temperature is lowered with cracked ice or ice water to between 0.5 and 5 degrees above freezing. By means of mechanical devices, the exact degree of refrigeration may be controlled, thus maintaining a definite margin of safety. This lowering of temperature preserves the tissues by halting cellular metabolism; the tissue cells are at absolute rest — a condition likened to hibernation or suspended animation. Inasmuch as inactive cells will not respond to stimuli, complete anesthesia is produced.

The first step in producing refrigeration anesthesia is the application of a tourniquet. Without it, the entrance of a little warm blood into an extremity would prevent complete refrigeration. Probably no subject in surgery is less controversial than the use of a tourniquet, but animal experiments leave no doubt that at ordinary temperatures the limbs can survive complete deprivation of blood without necrosis for twelve to fifteen hours. Allen and Crossman have reported an instance in which a badly ulcerated human leg had a tourniquet applied for six hours without apparent damage.[13] Direct pressure does produce tissue injury, as has been confirmed by Brooks and Duncan. Factors modifying pressure damage to tissues include the tension, the elasticity and the width of the tourniquet. Obviously only sufficient tension to check the flow of blood should be applied. Serious systemic shock may follow the release of a tourniquet that has asphyxiated large masses of tissue. As Mock[16] has pointed out, the histotoxins that form in asphyxiated tissues during the usual time a tourniquet is in place are insufficient to cause this. But badly traumatized tissues with impaired local resistance is capable of producing this histotoxicosis. Here the use of a tourniquet without refrigeration is hazardous and often fatal. Reduced temperatures obviate all the objections to tourniquets because the asphyxiated cells are at rest and are incapable of throwing off waste products.

Therapeutic Indications of Refrigeration

Use in Limb Amputations in Diabetes. — In 1942 Crossman and his associates[12] were the first to report a fairly large clinical series of cases in which the patients were subjected to amputation under refrigeration anesthesia. In this series of 45 cases there were 57 major amputations, with a mortality

15. Landis, E. M.: Capillary Pressure and Capillary Permeability, Physiol. Rev. 14:404 (July) 1934. Landis, E. M., and Gibbon, J. H.: The Effects of Temperature and of Tissue Pressure on the Movement of Fluid Through the Human Capillary Wall, J. Clin. Investigation 12:105 (Jan.) 1933.

16. Mock, H. E., and Mock, H. E., Jr.: Refrigeration Anesthesia in Amputations, J. A. M. A. 123:13 (Sept. 4) 1943.

rate of 12.3 per cent. All the patients were extremely poor risks for amputation, suffering from diabetes, arteriosclerosis or fulminating infection in gangrenous limbs. Pfeiffer and Patterson[17] reported a mortality of 11.1 per cent in 9 amputations through the lower part of the thigh in diabetics, their lone death occurring two weeks postoperatively and being due to pulmonary embolism. Their previous mortality rate in diabetic limb operations had been 28.5 per cent; thus with refrigeration there was a decrease in 17.4 per cent. Before the use of refrigeration, only half of the stumps healed by first intention; under ice anesthesia 66.7 per cent healed primarily. The average postoperative convalescent period was cut from 38.1 days to 22 days. These figures convinced them of the value of refrigeration anesthesia. Pfeiffer and Patterson concluded that refrigeration is ideal for those diabetics with gangrene who are aged, poor risks, toxic and in poor condition locally and generally. In the experience of Crossman and his associates, refrigeration anesthesia "has saved lives."[13] They concluded that this new life-saving method in the surgical treatment of peripheral vascular disease occasioned the patient no pain or loss of appetite, limited necrosis and stemmed infection in a gangrenous extremity and militated against postoperative thrombosis and embolism.[12]

Use in Gangrene Secondary to Arteriosclerosis or Peripheral Vascular Disease. — Refrigeration anesthesia is of inestimable value in the treatment of gangrene secondary to arteriosclerosis or to any peripheral vascular disease. Many aged persons fall into this group, and frequently they are so debilitated or weakened by sepsis that an anesthetic is a definite hazard to life. As Mock noted, many of them sorely in need of amputation are allowed to die because they could not possibly survive an operation. In arteriosclerotic and diabetic gangrene refrigeration anesthesia has produced its most brilliant results, and the use of an anesthetic which prevents and does not contribute to the shock of the patient is indeed a welcome innovation.

It occurred to Allen[18] that refrigeration might be efficacious in forestalling the spread of sepsis in these cases of gangrene. It has been known for a long time that bacteria are probably more sensitive to changes in temperature than to any other physical agent attacking them. Lowering the temperature would arrest bacterial activity, and application of a tourniquet would prevent the flow of toxins or bacteria from the infected limb. Because of the danger of releasing into the circulation an overwhelming accumulation of bacterial and tissue toxins on removal of the tourniquet, it was suggested that refrigeration of infected limbs be used to stem the infection until amputation was performed; an infected limb should not be refrigerated with a tourniquet unless amputation is contemplated. The preservation of tissue vitality, the bacteriostatic action of cold, and perhaps the high oxygenation of the blood and tissue fluids may explain the noticably high resistance to infection in these cases.[14]

Bruneau and Heinbecker[19] injected staphylococci subcutaneously or into the wrist joints of dogs, the limbs being immersed in water at 6 C. for twenty-four to ninety-six hours. Complete bacteriostasis at both superficial and deep tissue levels was evident from the bacterial counts at the end of refrigeration, which were practically identical with the number injected. While the temperature in the extremities cannot be lowered sufficiently by this means to produce death of bacteria, it can bring about inhibition of growth

17. Pfeiffer, D. B., and Patterson, F. M. S.: Refrigeration Anesthesia in Surgical Procedures, Pennsylvania M. J. 48:349 (Jan.) 1945.
18. Allen, F. M.: Experiments Concerning the Ligation and Refrigeration with Respect to Local Intoxication and Infection, Surg., Gynec. & Obst. 68:1047 (June) 1939.
19. Bruneau, J., and Heinbecker, P.: Effects of Cooling on Experimentally Infected Tissues, Ann. Surg. 120:716 (Nov.) 1944.

without cellular changes. This is in accordance with observations made by Temple Fay.[20]

Use Preliminary to Surgery. — Many patients with gangrene and sepsis of the extremities do poorly despite the best form of treatment. Septicemia with impending death frequently occurs. These patients are usually in too unsatisfactory a condition for any surgical procedure to be performed, no matter what anesthetic agent is employed. For them refrigeration may be a life-saving procedure. Immediate encasement of the affected limb will inhibit absorption of toxic products and prevent bacterial activity. A tourniquet may be applied immediately if there is no hope of saving the limb. However, in some cases the general condition may be so dramatically improved simply by the application of ice that conservative surgical treatment may be made possible. In these cases, naturally, a tourniquet should not be applied. Should the patient's condition be so improved that amputation is feasible after refrigeration for twenty-four to seventy-two hours or longer, a tourniquet can be applied and the limb amputated without the use of a further anesthetic agent. The application of ice in such cases cuts off the source of pain, toxemia and bacteremia as effectively as if an amputation had been performed.

Use in Treatemnt of Mangled Extremities. — Patients with badly crushed extremities are often in severe shock because of blood loss and absorption of toxic products from the mangled area. The classic example of emergency preservation after trauma by refrigeration is McElvenny's case[21] of a man with both legs amputated near the knees by a railway train, who arrived at the hospital with a blood pressure of 30/0. The stumps were packed in ice without a tourniquet for fifty-eight hours while he was treated for shock and pneumonia and prepared for operation. At that time the tissues, full of dirt, were still fresh and odorless; the muscles were red and healthy and blood clots were absent. The tissues had the appearance of a leg of beef which had hung in a refrigerator for days.

Dziob and Brown[22] reported a less spectacular care of traumatic amputation of one leg below the knee, in which pain, hemorrhage and shock were controlled by use of reduced temperature. Miyakawa[23] treated a miner in severe shock from an industrial accident in which a loaded coal car had run over his right upper tibia. After repair of ruptured bladder and urethra by immediate surgical measures, the leg was packed in ice for thirty-nine hours. The patient's strength having been built up, a midthigh amputation was performed with the limb under refrigeration; healing was by primary intention.

Most striking clinical examples of long preservation after trauma are Mock's reports[16] of pelvic fractures with iliac or femoral thrombosis associated with gangrene of a leg. The patient would die either from a thigh amputation under the conditions of shock and visceral injury or from delay if the gangrene were allowed to develop. The solution to this dilemma was met by preserving the legs with refrigeration for two weeks. Amputation at any earlier time would have been, in Mock's opinion, fatal; when the extremity was removed surgically two and one-half weeks later it was at a lower level than originally anticipated because of the development of collateral circulation.

20. Fay, Temple: Observations on Prolonged Human Refrigeration, New York State J. Med. 40: 1351 (Sept. 15) 1940.
21. McIlvenny, R. T.: The Effect of Cooling Traumatized and Potentially Infected Limbs, Surg., Gynec. & Obst. 73:263 (Aug.) 1941.
22. Dziob, J. M., and Brown, R. K.: Reduced Temperature Anesthesia for Surgery of Trauma, Indust. Med. 12:79 (Feb.) 1943.
23. Miyakawa, G.: Refrigeration Anesthesia. With Special Reference to Treatment of Severely Damaged Extremity Complicated by Visceral Injury, Am. J. Surg. 66:384 (Dec.) 1944.

Noteworthy is the treatment described by Ottaway and Foote[24] with a refrigerating apparatus on board a destroyer on active naval service. A shell fragment severed a man's femoral artery and vein below Poupart's ligament, making a large exit wound. Successful amputation of the affected leg was accomplished later upon transfer of the patient after refrigeration for twenty-eight days. Bowers[25] described benefits from refrigeration in cases of traumatic thrombosis of leg arteries in soldiers.

These brilliant reports offer adequate testimony that tourniquet refrigeration of badly crushed extremities retards shock and bacterial growth and permits the patient to be improved generally by plasma, transfusions, parenteral fluids and other shock-combating measures. While refrigeration cannot restore life to dead tissues, it can preserve traumatized tissues. Utilization of this principle in military and industrial surgery has been strongly advocated by Allen.[26]

Use in Treatment of Burns. — First to advocate reduced temperatures in the treatment of burns was Temple Fay.[27] Application of this principle was reported by Elman and his associates,[28] who carried out experimental studies on the influence of environmental temperatures on mortality in extensive burns. Rats under deep anesthesia were subjected to uniform severe injuries involving three-fourths of the skin surface. When they were kept at an environmental temperature of 75 F., the mortality was 25 to 32 per cent. When they were placed at 32 to 55 F. and at 99 F., the mortality was 100 per cent. These differences indicate the deleterious influence of heat and cold on the vital reparative processes and show that 75 F. is the optimal temperature for recovery. Consequently, the usual application of a light cradle in the treatment of burns may be definitely dangerous. Similarly, the treatment of shock must undergo a change in concept. Thus a fall in temperature in shock is not the result of anoxia but seems rather to be a well developed and useful protective mechanism which the traditional treatment combats.[29]

Allen and Crossman[30] in 1943 reported several cases of severe second and third degree burns in which refrigeration was employed. After the burns had been thoroughly cleansed and débrided and petrolatum pressure dressings applied, ice bags were then placed over the involved areas. When cold is to be applied, it is important to make the dressings very light. For this purpose electrical refrigeration equipment gives a more convenient, constant and dependable effect. Allen has stated[31] that the best emergency treatment for a burn is to plunge it into ice water or even cool tap water. In his opinion, this will avoid mechanical and chemical injury and control's pain, edema (including blistering and oozing), necrosis or seared tissue, infection and shock. Constitutionally these patients are not only transformed by the direct relief from intoxication but they also enjoy freedom from the usual narcotics, with consequent benefits to nutrition and strength. "Locally, the refrigeration of tissue and reduction of the need for skin grafts are beyond precedent," to use his words, "because of the improved recovery of partly devitalized tissues at the reduced temperature, and furthermore because of the avoidance of the destruction of such tissues by the usual débridement." According to Fay,[27] the advantages of the use of ice in the

24. Ottaway, J. P., and Foote, J. J.: Refrigeration of Wounded Extremities, U. S. Nav. M. Bull. 43:1041 (Nov.) 1944.
25. Bowers, W. F.: Refrigeration Therapy in Vascular Trauma, Mil. Surgeon 93:289 (Sept.) 1943.
26. Allen, F. M.: The Status of Refrigeration for Military Surgery, Arch. Phys. Med. 26:92 (Feb.) 1945.
27. Fay, T.: Cooling in Shock, J. A. M. A. 121:1109 (Mar. 27) 1943.
28. Elman, R.; Cox, W. M.; Lischer, C., and Mueller, A. J.: Mortality in Severe Environmental Burns as Affected by Environmental Temperature, Proc. Soc. Exper. Biol. & Med. 51:350 (Dec.) 1942.
29. Editorial: Cooling in Shock, J. A. M. A. 121:432 (Feb. 6) 1943.
30. Allen, F. M.; Crossman, L. W., and Safford, F. K.: Reduced Temperature Treatment for Burns and Frost-Bite, N. Y. State J. Med. 43:951 (May 15) 1943.
31. Allen, F. M.: Refrigeration in General Surgery of Limbs, Am. J. Surg. 68:170 (May) 1945.

treatment of burns are the following: 1. Pain is controlled. 2. Infection is prevented. 3. Shock is diminished. 4. Serum loss is decreased. 5. Toxic absorption is diminished. 6. Tissue destruction is lessened. 7. It does not interfere with any of the usual treatments of burns but it can be used in combination with them.[30]

Use in Fresh Embolism and Thrombosis. — Refrigeration has definite value in cases of fresh embolism or thrombosis. Allen has shown that a human limb can be kept bloodless and anesthetic below a tourniquet for at least eight hours and, the indications are, much longer, even up to forty-eight hours, without injury while the rest of the body remains warm. Nature's method in a lower extremity suffering from impaired circulation is to effect a cooling of the foot. Freeman,[9] Starr,[10] Lahz,[8] and Lewis[11] indicated that lower temperatures are necessary for maintainance of tissue vitality in extremities with impaired circulation. Former therapy of peripheral vascular disease was directed toward increasing peripheral circulation by the application of heat and increasing the oxygen content of the blood. The effect can be accomplished by the application of cold, which lowers the oxygen need of the cells and decreases local metabolism. As noted previously, acute circulatory accidents with thrombosis and embolism can be controlled by the use of local cold. The immediate anoxia becomes less dangerous, thus rendering the damaged extremity less liable to tissue necrosis and gangrene. If, after a fresh embolism, in addition to ice, a tourniquet is applied to the limb, the propagation of the thrombus at the tourniquet line is stopped, as is the inadequate collateral circulation. Cold preserves the vitality of the tissues and vessels, directly inhibits the clotting of blood and prevents adhesion of the thrombus to the vessel walls. Relief of segmental arterial spasm following trauma to a limb with concussion of the main artery is readily accomplished by refrigeration.[32] Cold abolishes pain and afferent impulses which excite spasm, and in sufficiently cold tissues the nerves cannot transmit and the smooth muscle cannot contract.

Postoperative embolism and thrombosis were not encountered in over 100 cases in which hypothermic anesthesia was used by Allen and Crossman. Pathologic examination has shown no structural change as a result of long refrigeration.[33]

Use of Cold in Immersion Foot and Frostbite. — Webster and co-workers[34] have credit for priority in the introduction of the use of cold in immersion foot. Immersion foot, which results from prolonged wetness at temperatures more or less above freezing, appears to be due to sublethal injury to the chilled tissue cells, the cutaneous arteriolar and capillary bed and the nerve fibers.[35] On removal from the water, such feet are cold and anesthetic, but these conditions are soon replaced by intense paresthesia and redness. Treatment consisted of elevation of the extremities and the application of cold. Marked relief of pain—due to anoxia of the injured superficial tissues and nerve endings[36] — occurred a few hours after cooling. Edema subsided, and all blebs containing straw-colored fluid and blood were resorbed. In the 142 cases described, almost all patients recovered with a minimal amount of tissue damage.

32. Hinchey, P. R.: Refrigeration in Surgery of the Extremities, New England J. Med. 230:63 (Jan. 20) 1944.

33. Allen, F. M., and Crossman, L. W.: Suggested Uses of Refrigeration Anesthesia Including War Surgery, Arch. Phys. Therapy 23:711 (Dec.) 1942. Allen, F. M.: Refrigeration Anesthesia for Limb Operations, Anesthesiology 4:12 (Jan.) 1943.

34. Webster, D. R.: Woolhouse, F. M., and Johnston, J. L.: Immersion Foot, J. Bone & Joint Surg. 24:785 (Oct.) 1942.

35. White, J. C.: Vascular and Neurologic Lesions in Survivers of Shipwreck: I. Immersion-Foot Syndrome Following Exposure to Cold, New England J. Med. 288:213 (Feb. 18) 1943.

36. White, J. C., and Warren, S.: Causes of Pain in Feet After Prolonged Immersion in Cold Water, War Med. 5:6 (Jan.) 1944.

In frostbite the tissues are frozen or "killed" by cold, subsequent death of affected tissues being due to irreversible physicochemical changes or to destruction by ice crystals.[37] It differs only in the degree of chilling and wetting from immersion foot, trench foot and shelter foot. Cases of Severe frostbite successfully treated by refrigeration have been reported.[38] Immediate relief of pain and subsequent complete healing of the frostbitten extremities occurred when the involved areas were placed in electrically refrigerated boxes. The most favorable temperature is between 60 and 80 F., as confirmed by a convincing unanimity of authors.[38] Refrigeration has been established as a standard treatment for frostbite, immersion foot and other injuries from cold, especially in Canada and England, owing largely to the pioneer studies of Webster, White, Bigelow, Ungley, Greene, Brownrigg and others.

Use in Skin Grafting. — The use of refrigeration has been extended to the field of skin grafting by Mock.[39] He employed refrigeration in 27 cases that required skin grafting. In each case ice bags were applied to the donor areas two hours before operation. No preoperative anesthesia was necessary. Complete anesthesia was obtained in 24 of the 27 cases. After the ice bags were removed, the site was cleaned with alcohol and the grafts removed. Refrigeration did not affect the growth of the graft or repair of the donor site. Mock recommended this new surgical method "because it is simple, time saving and efficient." Gaston[40] proposed the use of ethyl chloride for this purpose. Definite possibilities for refrigeration exist in this field.

Technic

The technic of refrigeration anesthesia is now becoming standardized,[13] though still undergoing some modifications.

One-half hour before the tourniquet is to be applied, the part is surrounded with ice bags in continuous contact with the skin. Application of the tourniquet to numbed tissue is not painful. After elevation of the foot to drain the leg of blood, the tourniquet is applied, ½ inch gum rubber tubing being used; it should be applied tightly enough to cut off all circulation without cutting into the skin or damaging the soft tissues. If the foot or extremity remains blanched, the hemostasis is complete. A rubber sheet is now tied around the leg or thigh 3 to 4 inches above the level of the tourniquet and extending down beyond the foot. Refrigeration is done immediately by packing cracked ice on the rubber sheeting completely around the extremity. Elevation of head of the patient's bed facilitates drainage of the melting ice into a pail. The ice should be replenished during the period of administration to make sure that the extremity is entirely surrounded by it at all times. If the amputation is below the knee, the leg may be put in a high pail.

To obtain the necessary degree of anesthesia, ice should be applied as follows: Low or mid thigh, two and one-half hours; upper third of leg, two hours; lower leg, one and one-half hours; toe or metatarsal, one hour. The ice is not removed until the operation is begun. Duration of the anesthesia is about one hour. This method of anesthesia does not limit the type of operation that may be necessary. When the ice has been removed, the leg is quickly dried without rubbing, prepared as desired and draped. The amputation is then carried out.

The tourniquet is retained until the main vessels are ligated. Then it is released, and all bleeding is stopped before closure of the stump. After a light but snug bandage is applied, ice bags are put on the stump for forty-eight to seventy-two hours. This lowers the metabolic requirements of the stump until adequate collateral circulation is developed and inhibits bacterial growth. Since agglutination of tissue fluids is retarded

37. Greene, R.: Cold in the Treatment of Damage Due to Cold, Lancet 2:695 (Dec. 12) 1942.
38. Allen, F. M.: Crossman, L. W., and Safford, F. K.: Reduced Temperature Treatment for Burns and Frost-Bite, New York State J. Med. 43:951 (May 15) 1943. White, J. C.: Vascular and Neurologic Lesions in Survivors of Shipwreck, etc., New England J. Med. 228:213 (Feb. 18) 1943. Ungley, C. C.: Treatment of Immersion Foot by Dry Cooling, Lancet 1:681 (May 29) 1943. Liebesny, P.: Physiopathology, Treatment and Prevention of Frost Injuries with Special Reference to Frost Injuries in Wartime, N. Y. State J. Med. 44:2118 (Oct. 1) 1944.
39. Mock, H. E., Jr.: Refrigeration Anesthesia in Skin Grafting, J. A. M. A. 122:597 (June 26) 1943.
40. Gaston, J. H.: Ethyl Chloride Spray for Freezing Donor Area in Skin Grafting, J. M. A. Georgia 33:151 (May) 1944.

by cooling, more serum than usual may seep from the stump and healing is slightly slowed. Because of this fact, sutures are not removed until twelve or fourteen days have elapsed.

Several authors have modified this technic. Gordon[41] constructed a refrigeration box lined with galvanized tin to be used in place of the rather untidy, wet and cumbersome rubber sheet. Crossman and others[12] are using an electrical refrigerator thermostatically controlled at 40 F. to obtain refrigeration, and Haley[42] has described a convenient metal cabinet to house the limb and cracked ice during refrigeration. Kennedy[43] adds the application of an Esmarch rubber bandage to drain the blood from the limb before the application of the tourniquet.

Cutting the sciatic nerve at the midthigh and sawing the femur are two procedures that test the adequacy of refrigeration anesthesia; generally the patient states that there is no pain. Many writers have commented on the fact that elderly, poor-risk patients are able to return to their rooms, sit up and eat their meals on the day of the operation. Sawing of the bone was so noisy that Newman[44] found it advisable to stuff the patient's ears with cotton. Mock[16] recorded an interesting case of a patient who immediately telephoned his brother on return from the operating room, joking with him about the simplicity of losing a leg.

Pneumonia is a definite complication from this method of anesthesia, particularly in aged, toxic and otherwise poor-risk patients.[14] Precautionary measures must be initiated immediately after the operation, as Richards emphasized.[45] Rarely, a patient may have a hypersensitivity to cold.[46]

The advantages of refrigeration in limb amputations or in the treatment of severely traumatized or ischemic extremities have been summarized by Allen[26] and by Shaar and Lehan:[47] (1) ease and quickness of operation; (2) absence of pain before, during, and after operation; (3) absence of shock; (4) inhibition of infection; (5) eating and other habits uninterrupted and constitutional strength thus maintained; (6) safety of low operation; (7) drainage, when necessary, facilitated by nonagglutination of wound edges; (8) postoperative sedation obviated; (9) increase in primary union of stumps, with shortened convalescence; (10) healthy final stumps; (11) preservation of poorly vitalized tissues; (12) direct inhibition of clotting, minimizing danger of thrombosis and embolism; (13) surgery permitted in poor-risk cases previously considered hopeless; (14) temperature, pulse and respiration unchanged under refrigeration anesthesia; (15) possibility of delaying of amputation until associated injuries and conditions which are threatening life receive the necessary treatment; and (16) multiple amputations made possible.[48]

Summary and Conclusions

Through the bold pioneer work of Fay and Allen, revolutionary concepts involving the use of reduced temperatures in limb amputations have now been established. Running counter to hoary precepts,[49] this new method of shockless ice surgery offers new hope to elderly, poor-risk patients with

41. Gordon, J. D. Refrigeration Box for Amputation, Am. J. Surg. 58:453 (Dec.) 1942.
42. Haley, E. F.: Refrigeration in Arteriosclerotic Gangrene, Arch. Surg. 46:518 (Apr.) 1943.
43. Kennedy, J. A.: A Technic and Device for Application of Ice Anesthesia for Amputation of Extremities, U. S. Nav. M. Bull. 41:226 (Jan.) 1943.
44. Newman, M. K.: Present Status of Therapeutic Hypothermy, Arch. Phys. Therapy 24:389 (July) 1943.
45. Richards, V.: Refrigeration Anesthesia in Surgery, Ann. Surg. 119:173 (Feb.) 1944.
46. Urbach, E.; Herman, M. F., and Gottlieb, P. M.: Cold Allergy and Cold Pathergy, Arch. Dermat. & Syph. 43:366 (Feb.) 1941. Walzer, M.: A Critical Review of the Recent Literature on Physical Allergy, J. Allergy 9:64 (Nov.) 1937.
47. Shaar, C. M., and Lehan, T. R.: Refrigeration Anesthesia, S. Clin. North America 24:1326 (Dec.) 1944.
48. Fralick, E. H.: Hypothermia in Military Practice, M. Clin. North America 27:1166 (July) 1943.
49. Lewis, S. T.: Vascular Disorders of the Limbs. New York, The Macmillan Company, 1936, pp. 9, 22.

gangrene of the extremities. The experimental stage is past;[50] more than fifty journals, representing hundreds of cases, agree in confirming the efficacy of this spectacular method. Marked reduction in mortality rates in amputations for diabetic and arteriosclerotic gangrene has resulted, rendering operations possible in cases previously considered hopeless.

As an editorial in the *Journal of the American Medical Association* for May 15, 1943, remarked, "Refrigeration anesthesia is an important advance in treatment." The reception of refrigeration anesthesia by the general medical profession was so uniformly favorable that the method has not been condemned by a single writer who tried it. Refrigeration was included as one of the twenty-seven principal medical advances for 1942 by the Surgeon General of the Army in a circular letter on Jan. 15, 1943.[26] But, in spite of the expanding use and approval, this method is still unknown or under suspicion in many quarters. Most investigators do not agree with the limitations to its use recommended by Neller and Schmidt[51] or with the conclusion of tissue injury reached by Richards.[45] The errors of Large and Heinbecker[52] have been pointed out by Allen and Crossman.[53] They condemned brief refrigeration for anesthesia without a single experience with it, experimentally or clinically.

Refrigeration is the chilling, not the freezing, of tissues. It abolishes protoplasmic reactivity, thus having unique value in prevention of shock. It is indicated for aged, poor-risk diabetic patients with gangrene of an extremity requiring amputation. Refrigeration is the choice of anesthesia in cases of gangrene secondary to arteriosclerosis or peripheral vascular disease.

Ice water anesthesia is often a life-saving procedure when gangrene, infection, toxicity and septicemia exist. Improvement of the patient's condition renders subsequent radical or conservative surgery possible.

Refrigeration of badly traumatized extremities retards shock and bacterial growth, giving time to overcome shock and to improve the patient generally. Amputation with no further anesthetic may then safely be performed.

Refrigeration offers many advantages in the therapy of burns, in case of embolism and thrombosis, immersion foot and frostbite and in the field of skin grafting. Miscellaneous uses of refrigeration are also considered.

A review of the literature was made in an attempt to condense modern concepts of refrigeration anesthesia into one short paper. The *modus operandi* of this method is explained, together with the results of animal experiments. The technic of refrigeration anesthesia for limb amputations is given.

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50. Crossman, L. W., and Safford, F. K.: Refrigeration for Anesthesia and Therapy, Mod. Hosp. 64:86 (Jan.) 1945.

51. Neller, J. L., and Schmidt, E. R.: Refrigeration Amputation, Wisconsin M. J. 43:936 (Sept.) 1944.

52. Large, A., and Heinbecker, P.: Refrigeration in Clinical Surgery, Ann. Surg. 120:707 (Nov.) 1944. Bruneau, J., and Heinbecker, P.: Effects of Cooling on Experimentally Infected Tissues, ibid. 120:716 (Nov.) 1944. Large, A., and Heinbecker, P.: The Effects of Cooling on Wound Healing, ibid. 120:727 (Nov.) 1944; Nerve Degeneration Following Prolonged Cooling of an Extremity, ibid. 120:742 (Nov.) 1944.

53. Crossman, L. W., and Allen, F. M.: Principles of Surgical and Therapeutic Refrigeration, Surg. Clin. North America 24:361 (April) 1945. Allen.26

An Optical Goniometer for Observing Range of Motion of Joints—Wilmer and Elkins

(*Continued from page 704*)

motion, it is clear that it would be more accurate to read an image of a limb on a lens, glass or photographic print.

The essential features for observing and recording range of motion of a joint include (1) a method reproducible by a second observer within a range of acceptable error; (2) maximal simplicity in construction and use of the instrument; (3) clearly established or enumerated criteria for the beginning and ending points of normal range of motion of each joint; (4) for practical purposes, an instrument which may be employed for most of the joints; (5) marking of bony landmarks; (6) recording of observations on blank pieces of paper, without preliminary review of past measurements for purpose of comparison.

Summary

An optical goniometer for measurement of range of motion of the major joints is described. It is essentially a reducing lens with a 360 degree scale attached.

The instrument was tested against unknown angles. There were 520 observations by twenty-nine physicians and eighteen technicians and secretaries. The standard deviation of the error of the physicians was 2.53 degrees. The mean and its standard error were —0.66 ±0.14. The physicians read 96 per cent of the angles on paper or the blackboard with an error of ±5 degrees or less, and read 49.5 per cent of the angles exactly. The control group of women observed 73.5 per cent of the angles with an error of ±5 degrees or less.

The device described deserves further study.

SEMINARS IN PHYSICAL MEDICINE

Postgraduate seminars in physical medicine have been held intermittently both in New York and Philadelphia some years ago, but it took progressive and hospitable Texas to successfully inaugurate yearly seminars. The fact that the Galveston sessions drew attendances from many other parts than the Southwest, proved the desirability of such instruction courses for other areas of this large country. It is pleasing to have this season announcements of physical medicine seminars for New York City, December 1 to 3, 1947, Kansas City, December 1 to 3, Chicago, Feb. 26 and 27, and that of the third annual seminar at Galveston, March 1 to 5. All these courses should draw capacity attendance and serve as further stimuli for the widespread and intelligent use of physical medicine by the general medical profession.

MEDICAL NEWS

Dr. Kendell Addresses Physical Therapists

The Illinois Chapter of the American Physiotherapy Association met at 7:30 P. M., Wednesday evening, Oct. 1, at Chicago Illinois Union, 715 S. Wood Street. Dr. H. Worley Kendell, Director of Physical Medicine, University of Illinois, and newly elected president of the American Congress of Physical Medicine, spoke on "The Role of the Physiatrist in Physical Medicine." The departments of physical therapy and occupational therapy at University of Illinois were open for inspection. Miss Viola Bryson, head physical therapist, Hines Hospital and vice-president of the association, reported on the conference in California, held in July.

Dr. Kendell stated that the role of physical medicine today is coming to be considered on an equal basis with surgery and medicine. The specialty has gathered impetus in the past five years through war, industrial accidents, physical therapy organizations and expansion in the Veterans Administration. The future, Dr. Kendell says, depends on education, research and a better understanding between the physical therapist and the physiatrist. The ideal is to integrate all phases of physical medicine and apply them so that the patient is the total recipient.

The next meeting of the Illinois Chapter will be Dec. 3, when Dr. Edmund Jacobson, University of Chicago and author of the book "You Must Relax," will speak to the group on relaxation.

VA News

Veterans Administration announces the beginning of a limited research program into the use of radioactive isotopes for diagnosing and treating certain types of diseases afflicting veterans.

Dr. George M. Lyon of Huntington, W. Va., as chief of VA's Radioisotope Section, will be in charge of the program.

To advise VA in matters of policy and planning in the research program, a Central Advisory Committee on Radioisotopes has been appointed.

This committee includes some of the nation's foremost authorities in medical research. Three of the members are particularly expert in the medical problems of nuclear fission. Members are:

Dr. Hugh Morgan, professor of medicine at Vanderbilt University, who was chief medical consultant to the U. S. Army during World War II.

Dr. Perrin Long, professor of preventive medicine at Johns Hopkins University, who was medical consultant to the Mediterranean Theater during the World War II.

Dr. Stafford Warren. professor of biophysics and dean of the School of Medicine, at the University of California at Los Angeles and formerly medical director of the Manhattan District and chief of the radiological safety sections at Bikini.

Dr. Hymer Friedell, professor of radiology of the School of Medicine, Western Reserve University and formerly assistant medical director of the Manhattan District.

The radioisotope program, during the next year, will be carried on at six VA hospitals. They are Framingham (Cushing), Mass.; Bronx, N. Y.; Cleveland (Crile), O.; Chicago (Hines), Ill.; Minneapolis, Minn., and Los Angeles (Birmingham), Calif.

At each hospital, the program will be under the general supervision of a Committee on Radioisotopes, which will be composed of prominent scientists from nearby universities participating in the VA medical program. These committees will be subcommittees of the local Deans Committees.

The radioisotopes program will bear the same relationship to the universities, and its administration will be similar to that for the medical care and for the residency training program for physicians within VA hospitals.

Dr. Allen on Medical Examining Board

Dr. Jessie P. Allen, Beloit, Wis., who has served three prior terms was reappointed by acting Governor Oscar Rennibohn as a member of the Wisconsin State Board of Medical Examiners. She is one of the original members of the American Congress of Physical Medicine. She is the only woman in the U. S. to serve on a medical examing board.

Burdick Corporation Shows New Equipment

Demonstrations were held by the Burdick Corporation at a special showing in Chicago recently of their new diathermy unit, approved by the Federal Communications Commission. Other equipment for physical medicine was also demonstrated.

Liebel-Flarsheim Issues Booklet on F.C.C. Regulations

The Liebel-Flarsheim Company, Cincinnati, has issued a 12-page booklet titled, "What You Should Know About FCC Approval to Medical Diathermy." The booklet is now being offered to physicians and surgeons throughout the nation. It is an informative booklet providing a simplified interpretation of the Federal Communications Commission regulations governing the operation of diathermy apparatus.

The Liebel-Flarsheim Model SW-227 Short-Wave Diathermy has been awarded FCC Type Approval No. D-472.

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ARCHIVES of PHYSICAL MEDICINE
OFFICIAL PUBLICATION AMERICAN CONGRESS OF PHYSICAL MEDICINE

∴ EDITORIALS ∴

MANIPULATIVE THERAPY

Human joints and the tissues about them are subject to many well defined pathologic states. More or less characteristic clinical and laboratory pictures are recognized in joint abnormalities caused by inflammation due to pyogenic, gonorrheal, tuberculous and other organisms; by trauma producing alterations of normal relationships and damage to surrounding tissue; by metabolic disorders; allergies; new growths, and by other diseases. The scientific minded practitioner accepts the existence of these abnormalities because they meet the criteria which permit them to be regarded as entities.

There are, however, other conditions affecting joints which give rise to pain and limitation of motion. Terms used to describe the nature of the involvement include "stiff joints," "locked joints" and "subluxations." Doubt is frequently cast on the correctness of this last diagnosis because X-Rays usually fail to reveal it. The other terms certainly do not convey any exact description of the condition. The pathology may at times exist in the tissues about the joint and not within the structures comprising it.

Many patients complaining of such pain and limitation of movement secure relief from manipulations applied by physicians and by others who do not possess the degree of doctor of medicine. The number of physicians who employ manipulative therapy is comparatively small, so that many a patient has recourse to the irregular "manipulator" in the effort to secure relief. Whatever the explanation, be it a psychic or massage effect, or due to a definite change in the relationship of opposed bony surfaces, the fact is that relief is frequently secured. Such observations are in the main subjective and empiric and therefore suffer from the lack of substantiation which may be obtained by a controlled series of cases or by one to which objective criteria can be applied. However, the commonness of these experiences and the long number of years which they have occurred, certainly create a challenge for the further investigation of this field by the regular members of the medical profession. The Baruch Committee wisely recognized this investigative need when on granting a large sum of money to one of our medical schools, it suggested that research be carried out in manipulative therapy.

Research properly conducted might well result in a clearer understanding as to what conditions might reasonably be expected to be improved by manipulation, and in what conditions this procedure is contraindicated. The cultist in his ignorance has done serious damage to many of those who have come to him for relief, as the orthopedist and the neurologist well know. It is of paramount importance to rule out the presence of pathologic states which cannot be remedied and may be aggravated by manipulations. The cultist who is incapable of making a diagnosis of conditions readily recognizable by a well trained physician may imperil the very existence of his patient by the direct damage he does to a diseased joint, or by denying the benefit which could be obtained through the use of proper medical, surgical or physical therapy.

Fortunately, there exists in our own ranks a medical practitioner who has devoted a long and active career to the determination of the possibilities and limitations of manipulations and the most effective technics by which they might be applied. He has ably presented the subject in the books which he has written and in articles, including the one which appears in the current issue of the ARCHIVES.[1] He has emphasized the necessity of first making a correct diagnosis by means of clinical, laboratory and roentgenologic examinations. He has warned against the use of haphazard manipulation inasmuch as (to quote him) "the movement of every joint in the body requires a special technique." These movements, he has shown, can be performed by the therapist and not by the patient himself.

As manipulative technics can best be learned by demonstrations and guided practice, Dr. Mennell has given courses of instruction to physicians in our country. These courses were extremely practical and proved to be very instructive. He is scheduled to continue such instructions in one of our West coast universities during the coming year. He is doing a great service to our specialty of Physical Medicine by conveying the information, which he has carefully and laboriously developed during many years to others, some of whom may carry on in the conduct of research which this field so sorely needs. While he is still with us, we should take advantage of his special skills and experiences to develop further the science and the art of joint manipulation by the study of the living anatomy of joints and by such other means as he may suggest.

1. Mennell, James: Manipulation of Stiff Joints, Arch. Phys. Med. 28:685 (Nov.) 1947.

DIPLOMATES IN PHYSICAL MEDICINE

The organization of an American Board of Physical Medicine, by authority of recognition by the Advisory Board for Medical Specialties, marks the consummation of many years of patient laboring towards that goal. The induction of the first group of diplomates in physical medicine at the recent meeting of the American Congress of Physical Medicine at Minneapolis, in the presence of the full eleven member board under the chairmanship of Dr. Frank Krusen, was an impressive occasion indeed. The functioning of the new Board and the requirements for certification[1] follow the precedents established by the other specialty boards and for the present the new Board will function under the guidance of a Committee of three of the Advisory Board, representing the American Boards of Internal Medicine, Orthopedics and Radiology. The verbal and oral examinations for certification are to be held twice a year, preceding the annual session of the American Medical Association and the September session of the American Congress of Physical Medicine. The diplomate in physical medicine is expected to possess knowledge in basic sciences and clinical training which may have been thought unattainable even ten years ago. The new Board properly made all possible allowances for the certification of older men, who have practiced honorably for many years in the field of physical medicine. It has bestowed honorary membership on four living pioneers: Drs. Edward C. Titus and Willard J. Travell of New York, James C. Elsom of Wisconsin and John W. Torbett of Texas.

Certification by the American Board of Physical Medicine should offer physiatrists new dignity and added responsibility in serving the public and the medical profession in the greatly broadened field of modern physical medicine.

1. American Board of Physical Medicine, Arch. Phys. Med. 28:531 (Aug.) 1947.

Medical News
(Continued from page 724)

Recess Appointments

Brigadier General George E. Armstrong, Acting Surgeon General of the Army, announces that the President of the United States has tendered recess appointments in the Women's Medical Specialist Corps, Regular Army, to the following physical therapists whose names appear on the first list of appointees in this new corps.

Public Law 36, 80th Congress, April 16, 1947, authorizes the establishment of a Women's Medical Specialist Corps to be comprised of a Dietitian Section, a Physical Therapist Section, and an Occupational Therapist Section. Officers in this corps enjoy all the benefits and privileges which are applicable to male commissioned officers of the Regular Army.

In order that all physical therapists who had previous military service in the Army may be assured of an opportunity to apply for integration in this corps, the Department of the Army has recently announced that the deadline date for submission of applications has been extended to November 30, 1947.

Bates, Myrtle M.	1 Lt.
Baylies, Marie H.	1 Lt.
Ben Dure, Mary L.	Capt.
Binning, Marcel	1 Lt.
Bundt, Francine B.	2 Lt.
Christman, Louis D.	Capt.
Clarke, Felie W.	Capt.
Desmond, Isabelle M.	Capt.
Fairbanks, Emily	Capt.
Harlan, Betty A.	1 Lt.
Harr, Emma T.	Capt.
Lawrence, Dorothea M.	Capt.
Lee, Harriet S.	Capt.
Mahoney, Margaret E.	1 Lt.
Moffitt, Inez	1 Lt.
Renfrow, Imogene	1 Lt.
Robertson, Barbara M.	Capt.
Snyder, Agnes P.	Capt.
Vogel, Emma E.	Maj.

Distribution of "Heavy Water"

The United States Atomic Energy Commission has announced plans for the distribution of heavy water and deuterium gas to qualified research institutions in the United States.

Heavy water was produced in connection with the atomic energy operation and now is available in sufficient quantities for domestic research purposes outside the goverment's atomic energy program. The Stuart Oxygen Company of San Francisco, which will make the distribution under contract with the commission, will convert heavy water to deuterium gas for applicants who need deuterium in the latter form.

Applicants for deuterium oxide (heavy water) and deuterium gas will be charged an amount sufficient to cover handling and distribution charges of the contract distributor. The price schedule for heavy water is 50 cents per gram for the first hundred grams and 30 cents per gram thereafter and for deuterium gas $1 per liter (at normal temperature and pressure) for the first hundred liters and 80 cents per liter thereafter. Prices are based on orders calling for single deliveries to the applicant.

Wanted: Books

Finland has an excellent and keenly scientific minded Technical Institute, Teknillinen Korkeakoulu. During the war its library was bombed and totally destroyed.

On my recent trip to Finland for the American Friends Service Committee, I discussed the situation with Dr. Martti Levon, Director of the Institute. He said he would welcome gifts of Scientific and Technical Books from America to take the place of those destroyed. In the remarkable efforts for recovery that the Finns are making, the lack of technical library facilities is a very serious handicap. It would be a practical act of friendship to a nation that holds America in high regard if Americans should contribute good technical books and periodicals to this library.

Any such gifts should be marked for the Institute of Technology, Helsinki, and sent to the Legation of Finland, 2144 Wyoming Ave., N. W., Washington, D. C. Dr. K. T. Jutila, the Finnish Minister, will arrange for their being shipped to Finland. (Signed) Arthur E. Morgan, Member, American Friends Service Committee, Yellow Springs, Ohio. P. S.—If you receive for review technical books that you do not wish to keep permanently, they would be appreciated as additions to this library.

Some Facts and Figures on Rehabilitation of Negroes

During the fiscal year 1946, the 51 state vocational rehabilitation agencies and the 30 commissions or agencies for the blind, rehabilitated about 36,000 persons in the continental U. S., Hawaii, and Puerto Rico. About 4,500 of these rehabilitants were Negroes and about 450 were members of races other than white or Negro.

More than one-half (56 per cent) of the 4,451 Negroes were rehabilitated by state rehabilitation agencies located in Region III. The State agency in Georgia with 688 Negroes rehabilitated, ranked first in the number of Negroes rehabilitated; the South Carolina agency with 530, ranked second; the North Carolina agency with 454, ranked third; the Alabama agency with 327, ranked fourth, and the Mississippi agency with 225, ranked fifth. The vocational rehabilitation agency in one territory, and eleven of the state agencies located in Regions 1, V, VII, and VIII reported no Negroes rehabilitated.

The Institute for the Crippled and Disabled Looks Forward

A study of the over-all rehabilitation needs of seriously disabled children is being made by the Institute for the Crippled and Disabled under a $25,000 grant from the Milbank Memorial Fund. A "Child Research Division" has been established to study what can be done to help disabled children—for the child of today is the man of tomorrow.

Vice Admiral McIntire Heads National Group to Employ Handicapped

Vice-Admiral Ross T. McIntire, former Surgeon General of the Navy, was elected president of the National Association for Employment of the Handicapped, succeeding Major General Graves B. Erskin, U. S. Marine Corps, who returned to active duty. Dr. Merle E. Frampton, principal of the New York Institute for Education of the Blind, became vice-president. Virgil Smirnow, assistant to the director of the B'nai B'rith vocational service bureau, was named executive secretary of the National Association of the Handicapped, Inc.

The National Blood Program

The goal of the new National Blood Program of the American Red Cross is to provide for medical use, without charge for the products, sufficient blood and blood derivatives throughout the nation to help save lives and prevent needless suffering.

Adoption of this program by the Red Cross in June of 1947 climaxed many months of intensive study and consideration on the part of medical and health leaders and the Red Cross.

Prior to its adoption the program was discussed with and approved in principle by the American Medical Association, the Association of State and Territorial Health Officers, the United States Public Health Service, the Veterans Administration, the Army, the Navy, the American Hospital Association and the Catholic Hospital Association.

Cerebral Palsy

Selecting the treatment and training of cerebral palsied children as its national service program for the year, Zeta Tau Alpha, has announced plans to cooperate with the National Society for Crippled Children and Adults.

As its principal project for the year, Zeta Tau Alpha will work with the Cerebral Palsy Division of the National Society in publishing an equipment brochure for which funds have been appropriated.

This much needed guide, which previously has not been available, will describe the various types of therapeutic equipment needed and used in cerebral palsy cases, and will include information pertaining to its construction and where it may be obtained.

Annual Meeting — American Occupational Therapy Association

The thirtieth anniversary convention of the American Occupational Therapy Association was held November 1 to 7, 1947, at the Hotel Del Coronado, California. Many interesting papers and discussions were presented among which were: X-ray motion pictures, Irving Rehman, Ph.D.; John H. Aldes, M.D., rehabilitation of paraplegics; Thomas G. Barrett, M.D., the importance of occupational therapy as a basic unit of physical medicine; Robert L. Bennett, M.D., report of occupational therapy in poliomyelitis.

A round table discussion on body mechanics was conducted. Dr. Eleanor Metheny presented body mechanics with the normal, and Miss Catherine Worthingham, presented body mechanics with pathologic condition; Beatrice Wade presented research in the field of psychiatry. Physical medicine and tuberculosis rehabilitation were topics of other round table discussions.

In conjunction with the general session there was held an institute on psychosomatic medicine and neuropsychiatry, November 6 and 7, which was conducted by Douglas G. Campbell, M.D., and Martha G. W. MacDonald, M.D.

New York Society of Physical Medicine

The following scientific program was presented at the regular monthly meeting for November of the New York Society of Physical Medicine: "The biologic and physiologic effects of ultraviolet radiation," Edward E. Gordon, M.D. Drs. William T. Anderson and Anthony C. Cipollaro discussed the presentation. Dr. Arthur S. Abramson presented the topic, "Bone changes in paraplegia and their prevention." Drs. Alexander B. Gutman and Leo Mayer participated in the discussion of Dr. Abramson's paper.

Meeting of Pennsylvania Academy of Physical Medicine

A meeting of the Pennsylvania Academy of Physical Medicine was held, Thursday evening, Oct. 16, 1947, at the Philadelphia County Medical Society Building, 21st and Spruce Streets, Philadelphia, Penna., Dr. Harold Lefkoe presiding. Dr. Irvin Stein, Instructor in Orthopedics, School of Medicine, University of Pennsylvania, spoke on "Painful conditions of shoulder joint." Dr. Robert A. Groff, Associate Professor of Neurosurgery, Graduate School of Medicine, University of Pennsylvania, spoke on "Diagnosis and treatment of shoulder pain."

Jessie L. Schepps

It is with regret we announce the death of Dr. Jessie L. Schepps. Dr. Schepps in addition to being a member of the American Congress of Physical Medicine, was also a member of the American Society of Physical Medicine and the New York Society of Physical Medicine.

BOOK REVIEWS

CRIPPLED CHILDREN IN AMERICAN EDUCATION. 1939-1942. By *Romaine Prior Mackie,* Ph.D., Teachers College, Columbia University Contributions to Education, No. 913. Cloth. Pp. 144. Price, $2.10. Bureau of Publications, Teachers College, Columbia University, New York, 1945.

In spite of the rapid advancement in medical science and in measures protecting the public welfare, there are still many crippled children. These children must be recognized by the educational system, and provision must be made for their special needs. Expansion of education opportunities for crippled children has been phenomenal in the first four decades of the current century, but the whole program is still inadequate and in a formative stage. Special education for crippled children has been developed and studies chiefly on a local basis throughout the United States. In this volume is brought together nation-wide information on the number, age, intelligence, disabilities, and other characteristics of crippled children in special schools and classes; the special services offered; educational practices such as course of study and its modification, making, promotion, and guidance; and personnel. Recommendations drawn from these findings offer a valuable guide to all those, both in schools and in homes, who are concerned with the development of the crippled child.

PHILOSOPHY AND MEDICINE IN ANCIENT GREECE. By *W. H. S. Jones,* Litt. D., F. B. A. Paper. Pp. 100. Price, $2.00. Baltimore: The Johns Hopkins Press, 1946.

This study discusses the prehippocratics and Plato, hypotheses in Greek thought, philosophy and medical etiquette and ancient medicine. In discussing the prehippocratics it states, "The prime motive, however, of Pythagoras was a desire to establish a society favoring or enforcing a special mode of life." Special stress was laid on the healthy mind to which the healthy body was but a means. The author says that no historian appears to have appreciated the unique position of Alcmaeon (500 B. C.) in the history of thought. He was more interested in medicine than in speculation.

There are many interesting things related. For example: "In the Charmides Socrates claims to have heard in Thrace, on the authority of Zalmoxis, its legendary hero, a certain medical theory of healing." The thoughtful reader is simply astounded by its modernity, which makes him wonder how such profound scientific thought could be born at such an early period in the history of research.

The young Charmides is suffering from a headache, and Socrates says that he had heard in Thrace that a physician cannot treat the eyes properly without treating the whole head, nor the head without treating the whole body, nor yet the body without treating the soul. The part can never be well unless the whole be well. Strictly speaking, of course, this statement is not true; Aspirin, without psychoanalysis will cure (or at least relieve) most headaches. But the principal or principles involved, that successful treatment of disease must not be limited to local symptoms, but must be based on a knowledge of the real cause or causes, physical or psychological, is of fundamental importance and profoundly true. Here we have yet another example of a guess verified and found correct by modern research.

This is a study that all physicians will find interesting reading.

FUNDAMENTALS OF CLINICAL NEUROLOGY. By *H. Houston Merritt,* M.D., Professor of Clinical Neurology, College of Physicians and Surgeons, Columbia University; Chief of Division of Neuropsychiatry, The Montefiore Hospital; *Fred A. Mettler,* M.D., Ph.D., Associate Professor of Anatomy, College of Physicians and Surgeons, Columbia University; and *Tracy Jackson Putnam,* M.D., Professor of Neurology and Neurological Surgery, College of Physicians and Surgeons, Columbia University. Cloth. Pp. 289. Price, $6.00. Philadelphia: The Blakiston Company, 1947.

The aim of this short text according to the authors is to explain the essential problems of nervous system disease encountered in general practice. The first section deals with the technic of examination. This includes method of history-taking and recording forms and the principle abnormalities to be watched for in the cranial nerves, motor and sensory systems, speech and other cerebral functions. Only unequivocal tests are discussed and simple anatomical diagrams are included.

In the second section basic anatomy is outlined together with brief description of the physiologic mechanisms which are disrupted in the commoner pathologic lesions encountered in the area discussed. Clinical descriptions are minimal and differential diagnosis omitted for the most part, but photographs of classical cases help minimize this omission.

The final section is concerned with the cerebral-spinal fluid findings and elaborates on the abnormalities in all the important lesions when lumbar puncture is indicated.

It is perhaps difficult to decide just where this text is most useful in medical education. It is too brief and devoid of references for the specialist and perhaps also for many medical students. The

important essentials are certainly clearly presented, but for the general practitioner for whom this book is intended more detailed discussion of the clinical picture and progress of disease would seem in order. There is almost no discussion of treatment, prognosis and management of the patient which is of particular interest to the practicing physician. The book would therefore seem best suited for the beginning medical student and as a review text for examination purposes or for occasional quick reference.

PRINCIPLES AND PRACTICES OF MEDICINE. By *Henry A. Christian,* A.M., M.D., LL.D., (Hon.) Sc.D., Hon. F.R.C.P. (Can.), F.A.C.P., Hersey Professor of the Theory and Practice of Physic, Emeritus, Harvard University; sometime Clinical Professor of Medicine, Tufts College Medical School; Physician-in-Chief, Emeritus, Peter Bent Brigham Hospital; Visiting Physician, Beth Israel Hospital, Boston. Sixteenth Edition. Price, $10.00. Pp. approx. 1643. Cloth. New York, London: D. Appleton-Century Co., 1947.

A medical sage who is a friend of the reviewer was examining a popular work on the history of medicine. After a ten-minute perusal he found a glaring error in the development of knowledge of the thyroid gland and put the book down with a smile.

"I don't think it can be done," he said. "It just isn't possible to write an accurate history of medicine."

The reviewer's feeling after reading extensively in this 16th edition of the "Principles and Practice" is likewise that a textbook of medicine cannot be written by one man. Of the few living medical encyclopedists, however, Dr. Christian is the only one who could in any measure approximate the task. The author explains his reason for writing the entire material (some 907,000 words) single-handed: ". . . A textbook should not be a mere condensation of the papers in medical journals, old or new, but rather the expression of the author's judgment of their correctness and value . . . a judgment based on his clinical experience and ability in the evaluation of the work of others. . . . What is written by him in the last analysis is a personal judgment of the value of the work of many in the field of medicine. . . ." A unity is achieved impossible to an editor of many contributions. In the English language only the monumental monographs on ophthalmology and the nervous system by Duke-Elder and Kinnier Wilson, respectively, are comparable.

Most practitioners say that they rarely use textbooks of medicine, so that the primary use for such a book is for medical students and interns. The text-book case, like the mean of a column of numbers, is an hypothetical figure never found in the original raw material. But beginners in medicine must have something brief enough to start on, which is provided by the textbook with its admitted defects.

The organization of the material and lack of illustrations (with exception of a few diagrams) are traditional. Authorities are seldom cited in the text, and references at the end of each section are brief and limited to important ones. Eponyms are properly avoided, and usually only historical names are noted.

The style is as simple as an old coat. It is no criticism to say that it does not approach the flawless Oslerian prose, for no modern medical writing ever does. The entire work gives the impression of hasty writing and hastier proofreading, as though the author were determined not to be more than 18 months behind the literature on his first articles by the time he had finished the last. By the time another printing is out these crudities, it is hoped, will have been corrected, but by then, alas, the whole work may again be out of date.

Twice as many pages (80) are devoted to tuberculosis as to malaria and syphilis. One might quarrel with this kind of emphasis from a world point of view, in which malaria is far and away the gravest disorder that afflicts mankind, although in the English-speaking world tuberculosis is still the greatest cause of death, excluding auto accidents, between the ages of 20 and 30.

No author of such a work could be expected to keep up with the latest in chemotherapy. The role of streptomycin in tuberculosis—where its results are discouraging—is discussed, while its use in influenzal meningitis—where it has scored its most spectacular successes—goes unmentioned.

Many sections on rare or exotic diseases are so brief as to do little more than list the names of the disorder. Some of the section on Metazoan Parasites and all that on Insects and Reptiles, Diseases Due to Physical Agents, and the Intoxications seem to have been inserted as an afterthought. The discussion of viral hepatitis seems much too brief for the importance of this common disease.

The discussion of the physiologic basis of the endocrine disorders is wholly inadequate. This is not an isolated defect, for it is equally true of all other textbooks of medicine with which the reviewer is familiar. But the most amazing omission is the lymphosarcomas — that protean and baffling group of diseases which so often turn up as the simulators of everything from meningitis to acute surgical disease of the abdomen. Hodgkin's disease is included, but only a 3-paragraph discussion of the other members of the group is found. There is no mention of the relation between leukemia and "lumps." The propriety of classifying this group of disorders as diseases of the lymph nodes may be questioned.

It is to be hoped that future editions will drop the section on Diseases of the Nervous System. It is far too brief and sketchy to be useful. Cerebral hemorrhage is discussed as though it were far commoner than cerebral thrombosis, when exactly the reverse is the case.

One might close with a final example typical of the disappointments repeatedly found in Dr. Christian's work—the consideration given the fascinating disease, rheumatoid arthritis. In spite of a bow to psychosomatic medicine in his Intro-

duction the author classifies it as a disease of the joints and brushes it off in a few paragraphs along with degenerative arthritis. (Incidentally, there will be no excuse from now on for any writer devising his own taxonomy of disease. The Standard Nomenclature of the A. M. A. is available to all.)

All will agree that degenerative disease is properly considered "just" a joint disease. But rheumatoid arthritis is a disease of the whole man and his personality, often with clinical and pathologic involvement of the central and peripheral nervous system, muscles, heart, liver, spleen, hematopoietic system, kidneys, skin, iris, serous cavities, and connective tissue. Many of these involvements are mentioned as complications, but the emphasis is all wrong.

Gastroenterologists will certainly quarrel also with the one-sentence discussion of "nerves" in the genesis of peptic ulcer and their complete omission from that of chronic ulcerative colitis.

Although it is gratifying to note the number of times the author mentions physical agents in the treatment of diseases in general, many of his suggestions have an archaic flavor. Most of us would hardly have the courage to employ as counter-irritants the cautery, blistering agents, or acupuncture. His unqualified condemnation of benzedrine in the treatment of obesity and his partial endorsement of cinchopen in arthritis are equally puzzling. The presentation of iron therapy in the iron-deficiency anemias needs revision. Studies with radioactive isotopes have shown that parenterally injected iron is quantitatively excreted as a foreign body.

On the credit side let it be said that considerable study was necessary to disclose the defects mentioned above. The book achieves the unity which the author intended. It is a remarkable monument to a remarkable man, the only one alive worthy to wear the robe of Osler.

One of its most fascinating features is the opening study by Dr. James C. Cass of the History of Medicine as told in Sixteen Editions of Osler's Principles and Practice of Medicine. There is a voluminous index.

CLINICAL TRAUMATIC SURGERY. By *John J. Moorhead,* B.S., M.D., D.Sc., F.A.C.S., (D.S.M.), Formerly Professor of Clinical Surgery, New York Post-Graduate Medical School, Columbia University. Second Printing. (Published June, 1945.) Pp. 747, with 500 illustrations. Cloth. Price, $10.00. W. B. Saunders Co., West Washington Square, Philadelphia 5, Pa., 1945.

This is the work of an outstanding clinician and teacher with extensive experience in traumatology, occupational accidents and war injuries. The first eight chapters deal with injuries in general, standard technics, shock, wounds and foreign bodies; injuries of the various body regions, joints and dislocations follow, then six chapters on fractures, five chapters on miscellaneous types of injuries, traumatic neuroses and war injuries; the final chapters present a detailed account of medicolegal phases of trauma, compensation problems and malpractice suits. While traumatic surgery has become virtually a specialty in many of the larger communities, the author rightly emphasizes that the majority of cases of injury always will remain a problem for the general practitioner. Accordingly the emphasis throughout the volume on two cardinal principles of traumatology: safety and simplicity. There are numerous illustrations throughout the volume but only a few references; the author believes that the average reader seeks primarily the opinion of the writer, and a treatment that is safely practical than the doubtfully impractical and unavailable. The advantages, as well as the drawbacks of physical therapy are briefly stressed; the author castigates its abuse in compensation cases by physicians who are neither experienced physical therapists nor surgeons of standing, but promoters of the M. & B. (massage and baking) racket. Moorhead's volume belongs to the library of every progressive physician and establishes a high standard for clarity, all-inclusiveness and dependability in a field in which very great progress has been made in recent years.

HOSPITAL CARE IN THE UNITED STATES. A Study of the Function of the General Hospital, Its Role in the Care of All Types of Illness and the Conduct of Activities Related to Patient Service, with Recommendations for Its Extension and Integration for More Adequate Care of the American Public. By *Commission on Hospital Care.* Cloth. Pp. 631. Price, $4.50. New York: The Commonwealth Fund, 1947.

We have boasted of our fine institutions, of the number of hospital beds per unit of population, and of the high standards of hospital care that exist in the United States. Yet both physical facilities and the arrangements under which they operate leave much to be desired. Many of our hospitals are old and outmoded. Some are housed in makeshift adaptations of buildings designed for other purposes. In many urban communities there is wasteful duplication of facilities created and continued by special interests, individual ambitions, and prejudices. There are many regions in the United States in which hospital care is quite inadequate. It is wholly lacking in some rural areas.

Emphasis has been placed on the care of certain special types of illness, but there is a partial, sometimes even a total disregard for the needs of persons suffering from other diseases. Advances in medical science have made it possible to prevent many diseases and many acute illnesses. However, there has been little increase in our knowledge concerning the prevention and treatment of chronic diseases and mental illness. In general there has been gross negligence in providing for the care of patients afflicted with these conditions.

We frequently refer to our splendid systems of hospitals, whereas actually there is none. Government units, church bodies, philanthropists, industries have participated in the construction of

hospital facilities. The diversity of background and objectives of the sponsoring interests has resulted in widely disparate patterns of organization, administration and control of hospitals. There is very little coordination. In some instances, there may even be competition.

This report is a guide to the future development of hospital care. The Commission has developed a plan for integrating and extending hospital service in a way which it believes is workable and desirable one which will strengthen and improve the present method of organization and distribution of hospital care. This report should prove useful in planning the expansion of hospital facilities throughout the country.

Under rehabilitation programs it is emphasized that hospitals should provide those facilities and services which will aid in restoring the patient to as full a measure of physical and mental health as possible and in eliminating or substantially reducing his disabilities as handicaps to employment. Rehabilitation services should include physical, psychologic and occupational therapy administered under skillful professional and technical direction.

This book is highly recommended and should be in the library of individuals and groups who are responsible for or interested in the improvement of hospital care.

ROCKY MOUNTAIN CONFERENCE ON INFANTILE PARALYSIS. Sponsored by the University of Colorado School of Medicine and Hospitals, and the National Foundation of Infantile Paralysis, Inc. Paper. Pp. 199. Price, $1.25. Denver, Colo., University of Colorado, 1947.

This report of a conference on Infantile Paralysis gives the latest works on its epidemiology; diagnosis, pathology and treatment. It should be read by everyone interested in the fight against infantile paralysis.

PURCHASING FOR HOSPITALS. By *Walter N. Lacy,* Purchasing Agent, St. Luke's Hospital, Cleveland. Cloth. Pp. 96. Price, $2.25. Chicago. Physicians' Record Co., 1947.

Little has been written or published primarily for the hospital buyer so this book has a definite place. To many, the job of securing what the hospital needs is one to which they can give but a fraction of their time. Per force they buy routinely, probably thoughtfully but often hastily. Institutions which are able to have full-time personnel for purchasing can do a better job in purchasing. The importance of doing it right has not too often been appreciated.

What is the size of the hospital and what budget warrants a procurement officer on its staff. The concensus of opinion of those authorities who have expressed themselves places 100 beds as the hospital size above which the institution should employ a purchasing agent with a purchasing department.

This book gives the reader some conception of the job of the procurement officer of a hospital, a glimpse of the need for cooperation with his fellow workers; a realization that others have the same complaints to contend with that he has; a new idea perhaps about his stock problems; and a suggestion that may improve his records.

ILLUSTRATIONS OF ANATOMY FOR NURSES. By *E. B. Jamieson,* M.D., Senior Demonstrator and Lecturer Emeritus, Anatomy Department, University Edinburgh. Second edition. Paper. Plates, 64. Price, $3.00. Baltimore: The Williams & Wilkins Company, 1946.

This is a collection of 64 color plates selected for the use of student nurses from the "Illustrations of Regional Anatomy" by the same author. The illustrations are uniformly excellent with adequate legends. They are sufficiently diagrammatic and simplified to serve their intended purpose. They are printed on heavy paper with ring binding for ease of use in the laboratory. This book is thoroughly recommended.

TUBERCULOSIS AS IT COMES AND GOES. By *Edward W. Hayes,* M.D., F.A.C.P., Associate Professor of Tuberculosis, College of Medical Evangelists, Los Angeles; Member of the Attending Staff, Los Angeles General Hospital, Division of Tuberculosis; Director of Tuberculosis, Imperial County, California; Medical Director and Physician in Charge of the Maryknoll Sisters Sanatorium, the Keane Sanatorium and the Lair Sanatorium, Monrovia, California. With Chapters by *Laurence dé Rycke,* Ph.D. Cloth. Second edition. Pp. 220. Price, $3.75. Springfield, Illinois: Charles C. Thomas, 1947.

Tuberculosis is as old as mankind and its contagious character was known at the time of Hippocrates, but this was largely forgotten until Koch in 1882 clearly demonstrated the role of the tubercle bacillus. The conception of rest as the basic principle of treatment developed only within our own generation.

The author of this volume, himself a former patient with tuberculosis sets out to convey to patients by clear cut writing and some 92 sketches, the cause and nature of the disease and the correct idea of its treatment. He describes fully all angles of the infection, illustrates the classification and the various pathologic changes of tuberculosis by simple drawings and briefly discusses the diagnosis. The main part of the little volume extensively describes all phases of treatment, mental and emotional rest, climate, time and the simpler modern operative procedures, with appropriate illustrations of the latter. It emphasizes an optimistic outlook of the prognosis and is written largely in non-technical language. This is a book which will enable the patient to discuss the details of his case intelligently with his physician and also to appreciate the reasons why he must follow the various phases of the cure his physician outlines. The information presented is authentic and dependable and should serve not only patients but also tuberculosis workers and physicians.

A TEXTBOOK OF BIOCHEMISTRY. By *Philip H. Mitchell,* Ph.D.; *Robert P. Brown,* Professor of Biology, Brown University. First Edition. Cloth. Price, $5.00. Pp. 640. New York and London: McGraw-Hill Book Company, 1946.

In this text emphasis is placed on those subjects, such as enzymes, intermediary metabolism, hormones and vitamins which have a direct bearing on metabolism—"the real chemistry of life." Particular attention is given to nutrition, since the author considers the chief present-day mission of biochemistry to be the establishment of nutrition as a science rather than as an art. Clinical or pathologic chemistry is considered only when study of the abnormal casts some light on normal function.

The book should be considered as a text only for those students who are well prepared in chemistry. The author believes that the student of biochemistry should have a background of physical chemistry as well as general and organic chemistry. For that reason, discussion of physiochemical matters is reduced largely to statements that will recall to the student the appropriate principles involved.

The book gives a good impression as a well-written, up-to-date elementary text. The usual topics, such as carbohydrates, fats, proteins and their digestion and metabolism are considered. In addition, there are chapters on photosynthesis, vitamins, absorption and detoxification, respiration and acid-base regulation, urine, foods and dietetics, hormones and chemotherapy. There is an introduction to biochemical literature which should prove a valuable guide and stimulus to the serious student.

MORELL MACKENZIE. THE STORY OF A VICTORIAN TRAGEDY By *R. Scott Stevenson.* Cloth. Pp. 194, illustrated. Price, $5.00. New York: Henry Schuman, 1947.

This book gives the truth behind the legends that have clustered around the association of Sir Morell Mackenzie, the English throat specialist, with his famous patient, the Emperor Frederick III of Germany, in 1887-88. German doctors attending Frederick, then the Crown Prince, had diagnosed a throat ailment as cancer and prescribed an operation, one that often proved fatal. In a dramatic, eleventh-hour consultation, Mackenzie advised against the operation and it was not performed. His diagnosis was an important point in European history, for if Mackenzie had succeeded in prolonging Frederick's life, as Emperor he might have built a liberal instead of a reactionary Germany, and years of conflict, bitterness and agony might well have been avoided. But he reigned, a sick man, for only ninety-nine days.

Had Mackenzie, like another Warwick taken on himself the role of kingmaker? Was his diagnosis made in good faith, or was he influenced by others, as has been alleged, for political reasons to pronounce decisively against the previous diagnosis, so that the Emperor might ascend the throne, if only for a brief period? The lucid and fully documented pages of this book provide a definitive answer to these questions. As the story unfolds, it presents in convincing dimensions such outstanding personalities as Bismarck, the great pathologist Virchow, Queen Victoria and Mackenzie himself, all performing their roles against the rich tapestry of the Victorian Age.

PSYCHIATRIC INTERVIEWS WITH CHILDREN. Edited by *Helen Leland Witmer,* Ph.D. Cloth. Pp. 443. Price, $4.50. New York: The Commonwealth Fund, 1946.

In this interesting book, the editor, a social worker, has collected a number of examples of the way in which psychiatrist and case worker form a team in the treatment of children. The material is presented in considerable detail and demonstrates the way in which information is obtained and therapy is carried out at the same time. Child psychiatry is coming into increasing prominence not only because of the encouraging results with individual children, but also, and much more importantly as a field in which prophylactic technics are being evolved which will make for a lessened incidence of neurosis and difficulty of adjustment in adult life. This book is an excellent addition to the literature of this specialty.

HUMAN EMBRYOLOGY. By *Bradley M. Patten,* Professor of Anatomy in the University of Michigan Medical School. Cloth. Pp. 776, with 1,366 drawings and photographs grouped as 446 illustrations, 53 in color. Price, $8.00. Philadelphia: The Blakiston Company, 1947.

This new textbook of human embryology is especially designed to hold the interest of medical students and physicians. This is accomplished by omitting comparative and theoretical material in favor of correlations with physiologic functions. This is particularly evident in the chapters concerning the nervous system and the circulatory system. Another factor of considerable interest to the clinician is the inclusion of considerable material on congenital anomalies.

The text is liberally illustrated with footnotes and diagrammatic sketches which are excellent. The illustrative material in a text such as this is of prime importance and adds tremendously to the value of the book. An abundant bibliography is appended. This book is highly recommended as a textbook for the use of medical students and as a reference for physicians.

PHYSICAL MEDICINE ABSTRACTS

Physical Therapy in the Treatment of Arthritis. L. Maxwell Lockie, and Earnscliffe Musgrove.

New York State J. Med. 47:851 (April 15) 1947.

The program of bed rest and organized exercise is continued preparatory to weight bearing. Special attention is given to foot exercises which are simple and must be performed carefully and systematically. Consideration is given to shoes which must be well supported, must fit properly and be worn from the initiation of the weight-bearing exercises. At this stage any necessary supports, such as parallel bars, crutches and walker, may be used; but these devices are only temporary and used in the interim between complete bed rest and restored function.

In the transition from bed rest to sitting, standing, and walking, body alignment is stressed and fatigue must be minimized. Preliminary exercises are continued aiming at postural stability in the sitting position before standing or walking is attempted. The exercises have strengthened the patient so that he may sit over the edge of the bed or in a suitable chair maintaining good posture.

The factor of the patient's home adjustment is emphasized in this program. His mental repose and muscular relaxation continue to receive constant attention. The patient becomes posture-conscious and derives pleasure from his exercise regimen. He is kept busy and interested during his convalescence and now approaches the objective of caring for himself and assuming old habits modified to suit his new routine.

While the patient was in the hospital, plans have been made for the management of his care and treatment at home. Some member of his family, who has followed the program and realizes its importance, is given instructions. Rest, heat, and exercise in their simplest form are continued at home, and there rest must still be adequate. A definite number of hours are spent in bed. If fatigue is apparent, a longer time in bed is indicated. Heat by means of an infra-red lamp is applied regularly, two or three times daily. The heat must be mild and the distance at which the lamp is used should be considered (30 to 36 inches). Exercise is still of great benefit and, now, also takes the place of massage. The routine is worked out to suit the new environment. General postural and breathing exercises are continued and individual joint exercises performed at regular intervals. Activity is increased gradually with care to avoid fatigue. Climbing of stairs is avoided for some time. Occupational therapy solves much of the problem in regulating activity.

Patients with rheumatoid arthritis and osteoarthritis show the greatest improvement if a specific program adapted to their individual needs can be carried out intensively, and can be continued at home. It is of extreme importance in the successful management of the case to be sure that the patient has a good understanding of the whole program of his treatment.

Orthoptics. Walter B. Lancaster, and Julia E. Lancaster.

J. A. M. A. 133:1211 (April 19) 1947.

The following has been adopted by the Council on Physical Medicine:

To summarize the task of the orthoptist:

Be sure that the patient has sufficiently good vision in each eye. The patient must learn to fix with either eye at command and hold fixation for the count of fifty. In most patients the first step toward binocular vision is learning to overcome suppression. The patient must begin to use his two eyes together. Meantime, the patient may have anomalous correspondence. If so, this must be corrected. When the patient has learned to use his two eyes separately without suppression it is time to see if he can fuse the two images. Amplitudes of fusion must be developed by vergence exercises, of which there is a variety.

With the major amblyoscope, the orthoptic technician has the situation firmly under control. There are no extraneous stimuli entering the situation. The technician can control the lights and movement of the instrument and can control the stimulus by the choice of targets so that the patient is almost forced to make a correct response. Once he makes that response he is praised for it and encouraged to repeat it. Thus the patient learns. This is orthoptics.

Extremity Refrigeration Without Tourniquet Ligation in Cases of Acute Arterial Deficit. Kenneth E. Livingston.

Ann. Surg. 125:431 (April) 1947.

Following an acute and severe vascular accident secondary to traumatic aneurysm of the popliteal artery, cooling of the distal extremity was carried out for a period of twenty-eight days prior to amputation. During the interval of observation, changes which were assumed by all observers to have been irreversible regressed, and the appearance of the foot strikingly improved. Following amputation there was gross and microscopic evidence that revascularization was taking place in the cooled tissues and that the nutrition of the deep muscle tissues and weight-bearing skin and subcutaneous tissue of the foot had been well-maintained. These studies did not indicate that the smaller circulation in the cooled areas had been extensively shut down by vasoconstriction due to cold.

Artificial Sunlight Treatment in Industry. A Review. William Beaumont.

Brit. J. Phys. Med. 10:48 (March-April) 1947.

The comments on artificial sunlight in general appear to be unnecessary in a report on a scientific investigation. The statement that "the findings of this report provide no evidence one way or the other in regard to the value of ultraviolet light as used to treat particular diseases . . ." is difficult to reconcile with the analysis of the treated and control groups, classified according to particular diseases under the headings of "respiratory infections (excluding colds)," "infections other than respiratory," "debility and anemia," "rheumatic complaints," "gastric disorders" and of such symptoms as "energy," "appetite," "sleep."

The purpose of the "historical survey" appears to be to throw doubt on the value of investigations carried out by eminent medical men, not only in Great Britain but in the United States of America and in Sweden. However justifiable this may be in other quarters, its inclusion in a report on a particular investigation of this nature is at least problematical.

The Fundamental Position of Rest, Its Use in Certain Conditions of the Spine, Especially Sciatica. Aladar Farkas.

Brit. J. Phys. Med. 10:42 (March-April) 1947.

So far, little attempt has been made to determine the optimal position of rest for the spinal column. The only established fact is the tendency of injuries, as well as of inflammatory conditions of the spine, to produce kyphosis in the lumbar and cervical segments and to increase the thoracic kyphosis.

Turning from the strictly pathologic to the semipathologic condition of advanging age, the question arises as to how the spine is affected by the process of aging, the slowly corroding traumata of occupation and the totally neglected position of the body in simple rest or rest of relaxation. During the process of aging, the tendency effective under traumatic or inflammatory conditions is duplicated, causing the thoracic kyphosis to increase and the lumbar lordosis to diminish or to disappear entirely.

The relative or absolute occupational kyphosis of the lumbar spine is initiated by the lateral abdominal muscles, the quadratus lumborum, the psoas and, to some extent, the anterior abdominal muscles. The maintenance of the occupational position is achieved by the same muscles and is reinforced by gravitation. The fixation or stabilization of the occupational position is brought about by the tetanic state of the muscles surrounding the spine and preserving its kyphotic contracture. The shrinkage of the ligaments and fascia appears at a later stage. The damage inflicted upon the spine with regard to its shape and structure is accentuated by advancing age, a factor which later becomes predominant, depriving the spinal system of the possibility of complete recovery.

The diminution or disappearance of the physiologic lumbar lordosis is ascribed to occupational traumata and to the habitual mode of rest. The low back syndrome is explained on the basis of the conversion of the lumbar lordosis into kyphosis, rendering low back pain one of the most widely spread chronic diseases in the higher age groups.

The slanting bed, that is a bed the front legs of which are elevated five to twenty inches, affords the spine the greatest amount of rest and reestablishes the lumbar lordosis, at the same time relieving all the subjective and most of the objective signs and symptoms of low-back pain within a relatively short time, as has been proved in over 150 cases.

Differentiation between normal kyphosis and kyphotic contracture of the lumbar spine in sciatica is analyzed by means of x-ray films.

Scalenus Anticus Syndrome. M. Gage, and H. Parnell.

Am. J. Surg. 73:252 (Feb.) 1947.

Patients with pain in the neck, shoulder, arm and forearm, with numbness and tingling in the thumb, index, ring or little fingers associated with muscle weakness, should have a thorough neurologic examination of the muscles and nerves of the involved extremity. The scalenus anticus muscle on the involved side is painful to palpation and pressure in all patients exhibiting the syndrome. If pain is not present on pressure over the lower portion of the scalenus anticus muscle, the patient probably does not have scalenus anticus syndrome. The condition must be differentiated from subacromial bursitis, brachial plexus neuritis, arthritis of the cervical spine, herniated cervical disk, rupture of the supraspinatus tendon, sympathalgia of the cervicodorsal type and cervical rib. The conservative treatment of scalenus anticus syndrome consists in correction of poor posture, massage, diathermy, rest of the upper extremity, injection of the scalenus anticus muscle with procaine hydrochloride and sleeping on three pillows. If conservative treatment fails, scalenotomy with partial resection of the scalenus anticus muscle is indicated.

Rehabilitation in Chest Injury. Frank Cooksey.

Proc. Roy. Soc. Med. 40:287 (April) 1947.

Rehabilitation can be divided into two main sections, general and local, that is, the handling of the patient as a whole and the more local restoration of chest functions.

The patient, on admission to chest hospital or unit, may develop after some weeks or months a physical and moral lethargy which must be combated at every turn if the general condition allows. The necessity for maintaining chest cases in bed for a long period is not usual and most patients can be up and about for a considerable period of the day once the acute stages of illness are over. They should not be allowed to slouch around the wards in dressing gown and

slippers, but should dress, wear shoes, and in general comport themselves as ordinary individuals.

The most difficult part of the general treatment, however, is the psychologic aspect. The patient who is at first interested and energetic may easily become apathetic in a period of time, and deteriorate into that unfortunate state known as "hospitalization."

The much more technical aspect of rehabilitation for the thoracic worker is concerned with actual chest functions. The exercises to reestablish chest movement are essentially based on inspiratory efforts. The old idea of using blowing efforts to aid reexpansion of lung are almost valueless and should not be employed. The active inspiratory exercises that have been devised depend on the establishment of energetic and localized movement of the part of the chest wall indicated. The physical therapist, having analyzed the deformity, or in the case of an empyema, the area of the dead space, starts by making pressure with the hand over the chest wall, and encouraging the patient to expand and even actively push that hand away.

Management of Strabismus. Edmond L. Cooper.

J. Michigan M. Soc. **46**:305 (March) 1947.

The subject of strabismus is one which should be of interest not only to ophthalmologists but to pediatricians and general practitioners as well. This is known to be so since probably two-thirds of the cases of strabismus seen by ophthalmologists are referred by the family physician or the pediatrician. It is they who see the patient first, it is to them that the parents of stabismic children are most apt to turn for first advice, and it would seem that they should be interested in giving advice backed up by an adequate understanding of the condition.

Two types of exercises are useful in the treatment of squint, the first to develop vision in an amblyopic eye and the second to develop and increase the amplitude of fusion.

The first type of exercise is the most important. Children who alternate, develop equal vision in both eyes and so do not need this type of exercises. But children who do not alternate, and this includes the majority of children with strabismus, invariably have poor vision in the turning eye and after necessary glasses have been prescribed no time should be lost in beginning its development. It should be remembered that the amblyopic eye has poor vision simply because it has not been used. Therefore, the remedy is easy. The good, or fixing eye, is simply covered with a patch and thus the child is forced to use his amblyopic eye.

The length of time required to develop vision in an amplyopic eye depends on the age of the patient, the cooperation of himself and his parents and the amount of refractive error. A young child, under three or four years, may develop normal vision in the amblyopic eye within a month if he wears the patch and his glasses faithfully. In older children it takes longer and at the age of ten or twelve it may take six months or a year.

The second type of exercises, to develop the fusion sense, requires more patience and skill on the part of both the patient and the physician. Most children do not respond to fusion training until the age of five or after. It requires some intelligence and some children are never apt pupils.

The Effect of Ultraviolet Irradiation on Various Properties of Influenza Viruses. Werner Henle, and Gertrude Henle.

J. Exper. Med. **85**:347 (April) 1947.

The effect of ultraviolet irradiation on various properties of the influenza viruses Types A and B has been analyzed. The studies involved propagation and interference in the allantoic sac of the chick embyro, inhibition of embryonic development, toxicity for white mice, hemagglutination including the adsorption-elution mechanism, immunizing capacity for mice and complement fixation activities in the presence of antibodies to the 6008 antigen (human convalescent and postvaccination sera) and the 308 antigen (convalescent sera only). It has been shown that the various activities of the influenza viruses were affected by irradiation at different rates, indicating that they are based, at least in part, on different constituents of the virus particle. On account of these differences in the susceptibility of the various properties to ultraviolet light it was possible (a) to differentiate between the interference phenomenon as observed in the allantoic sac, and the development of nonagglutinability in red cells by either homologous or heterologous fresh virus, and (b) to separate individual steps involved in the mechanism of infection of susceptible host cells. The implications of these observations are discussed.

Effect of Ultraviolet Air Sterilization Upon Incidence of Respiratory Infections in a Children's Institution — A Six-Year Study. Reginald A. Higgons, and Gertrude M. Hyde.

New York State J. Med. **47**:707 (April 1) 1947.

The authors present a short review of the literature.

After a rather careful search of the literature, the children's building of St. Luke's Convalescent Hospital is the first institution of its type to install these lamps throughout, so that every cubic foot of air in the whole building is subjected to a sterilizing effect equivalent to more than 100 complete air changes per hour. The children are never exposed to unsterilized air, day or night, except when outdoors. The authors believe that complete coverage of the whole building is essential as it has been shown that air currents from unsterilized portions of a building may carry pathogens to the children in distant locations, and also may infect children in transit through the unsterilized areas. Early in the study an attempt

was made to correlate the diminution in the output of the bulbs with the incidence of infection.

During January, 1944, there was admitted a child with unrecognized pertussis, and simultaneously there developed 5 cases of pertussis among the inhabitants of one run-around ward with a census of twelve. No other cases developed elsewhere in the institution among a census of 25 children, although the diseased cases were kept in the institution throughout.

In November, 1944, a case of chickenpox developed in the preschool age group which numbered 12 children, all of whom slept in the one room. It was interesting to observe that only 4 of the 12 children contracted the disease although all were susceptibles according to their histories. Each of these 4 contact cases contracted the disease individually at intervals of fourteen days or longer. No other cases developed in the remainder of the institution.

One case of scarlet fever and 1 case of mumps occurred during the experimental period without any secondary cases of either disease.

The unreported experience of the authors for the winter of 1945 to 1946 follows the same general pattern as that of the reported years, in spite of the fact that the incidence of respiratory disease in the community reached epidemic proportions in this period.

Origin and Development of the Erect Posture. Clarence A. Splithoff.

Surg., Gynec. & Obst. **84**:943 (May) 1947.

Human posture is shown to have evolved through a series of progressive changes, beginning with the prehistoric Devonian fish, 350 million years ago. Changes occurred which allowed the ancient amphibians some 50 million years later to become land dwellers. Because of poor adaptation to terrestrial locomotion their efforts were probably limited simply to obtaining food with little attempt made to move for any distance.

Walking continued to be cumbersome in the ancient reptiles, whose limbs were widely spread apart and not yet well adapted for land use. However, progress was made by evolutionary changes and there evolved a creature between the reptile and mammal, which was actually able to run on land. From this Cynognathus which existed 175 million years ago has evolved the more highly developed Notharctus an arboreal monkey-like mammal.

The Notharctus was one of a great group of primitive primates and as such may be considered a representative progenitor of the order of primates to which man belongs. The ability to climb trees was possessed by this animal and later by other lemurs, monkeys, and apes. The only ape able to walk upright on the ground is the gibbon, an East Asiatic tree living descendant of the first family of man-like apes. The skeleton of this ape begins to appear almost human in type. Nature first endowed this ape with the ability to walk by up-ending one tower of the suspension bridge to which the shoulder and pelvic girdle, together with the spine, may be compared and balance it on its rear tower, represented by the pelvic girdle. The ability to walk upright was evolved from the habit of sitting upright and by the habit of brachiating or swinging from limb to limb.

The ability to walk has been perfected in the human through modification of the entire skeleton, but principally the pelvis and lumbosacral spine. It is true that certain apes can walk upright, however, this gait may not be natural for them because the pelvis is not mechanically suited for such progression. The muscle pattern of ape and man is similar, yet there is a difference in function and in comparative size; and a difference in the focal point of action of the gluteal muscles which is the secret of human ability to walk. In the ape the external iliac surface points backward at right angles to the acetabulum, rather than externally or outward as in the human.

Thus human posture was evolved by progression from water on to land, then into the trees and to the ground again, and as this progress was made the skeleton was conditioned to the habits of the animal or the uses to which it would be put.

Diathermy Machines. Allen C. Stephens.

M. Ann. District of Columbia **16**:180 (April) 1947.

Diathermy now causes serious radio interference. The F.C.C. can stop an interfering machine from operating. Interference can be stopped by complete shielding or by getting a machine which meets the new regulations. The new regulations are in the public interest and safety. Physicians can cooperate with their local communities by making sure that their machines meet the F.C.C. regulations. The full effect of enforcement of these regulations by the F.C.C. will probably be felt within two years. It is suggested that, prior to purchase, a written statement be obtained to the effect that a machine does meet the F.C.C. regulations, the exact extent thereof, and how the machine will be marked with this information. It is important that service be available in order that if the machine should begin to operate outside its approved limits, the cause may be remedied without delay.

Supraspinatus Syndrome. G. C. Tippett.

Lancet **6443** (March 3) 1947.

The author cannot entirely agree with the view that surgery alone will cure a third of the cases which do not cure themselves. Physical therapy for the supraspinatus lesion has been dismissed by some as useless. While agreeing that radiant heat is a waste of time, long-wave diathermy, with one pad applied over the supraspinatus muscle belly and the other over the acromial bursa, will produce great relief from pain. However, a treatment with more dramatic effects is the production of three Kromayer burns in the line of the tendon, repeated after some weeks if the first application has not cured. This treatment has

cured most cases of supraspinatus tendinitis. Operation on the tendon sheath, with scraping or excising of the calcified area, produces intractable stiffness. With arthritis of the acromioclavicular joint, which the author never can cure by any physical therapy, excision of an inch of the acromion appears a suitable procedure.

The Place of Physical Medicine in the Treatment of Patients With Mental Conditions. Benjamin Simon.

New York State J. Med. 47:854 (April 15) 1947.

In ascending order of importance physical therapeutic technics fall into three groups. The first is in most hospitals recognized as "physical therapy" and is performed by or under the supervision of trained physical therapists. In general, it is directed at specific physical disorders. A priori, any improvement in the physical status of the neuropsychiatric patient necessarily reflects in his mental and emotional state. No amount of psychotherapy can be fully effective on patients who have old fractures, arthritis, bursitis, myositis, sacroiliac strains, sinusitis and other such conditions. In such cases the use of diathermy was effective. Those conditions involving muscles and joints were followed up with graduated passive to active exercise on the plinth and then on to more active exercises in the reconditioning gymnasium equipped with a rowing machine, bicycle, pulleys, stall bars, weights, parallel bars and, above all, competent, trained instructors. This produced in addition a great sense of well-being in the patients. Not the least advantage from this work was the group effect.

Counter-Irritation. W. H. Wynn.

Practitioner 945:185 (March) 1947.

Fibrositis and non-specific arthritis are particularly suitable subjects because of the comparatively superficial position of the lesions and the poor peripheral circulation. In acute lumbago, injection of the localized painful areas with 2 per cent procaine has an immediate effect, in which the acupuncture no doubt plays a part, and this can be followed up with heat. In chronic fibrositis the local anesthetic will have only a temporary effect but will provide an opportunity for firm massage. Heat is the best form of counter-irritation and the choice of method is one of convenience. As most patients are treated at home a simple method which can be used by the patient is preferable. The application of a hot flatiron over brown paper has long been a homely remedy and hot sandbags can be used when electricity is not available. Infra-red irradiation has been the most useful for home use. It should be applied every day for half an hour at bedtime. For institutional treatment, when skilled staff and apparatus are available, short wave therapy with its power of directly heating the deeper tissues is of great value in relieving pain but has the disadvantage of unduly heating the highly resistant subcutaneous fat. Inductotherapy can be used for local treatment if the area is not too small.

Joints are peculiarly adapted to respond to an increased blood flow. Over the knee joint, for instance, several arteries anastomose to form a superficial wide-meshed network of fine vessels between the skin and fascia, and a deeper seated network of larger vessels in contact with the bones sending numerous offshoots into the joint. At a later stage, when the need is for the absorption of exudates and inflammatory thickenings, an increased blood flow can be obtained by infra-red rays, radiant heat, or baths of paraffin wax. Short wave therapy has been advocated specially for gonococcal arthritis but has a wider range. Blistering and cauterization are still advocated but have no advantages. Before the introduction of salicylates the swollen and painful joints of acute rheumatism were often treated by applying a strip of blister an inch wide around the limb, just above and below the joint.

Except for histamine, the introduction of drugs by ionization is now little used, but the continuous current can be used for the relief of pain.

Physiotherapy and the Athlete. J. E. Lovelock.

Practitioner 945:226 (March) 1947.

An athlete is defined in the original Greek conception as one who takes part in any contest or struggle (C.O.D. 1931 — competitor in physical exercises); it is not interpreted in the narrow sense of a track or field Athlete. Competition with its emotional urge and its intellectual control is essential to the conception of an athlete.

The subject could be taken to embrace the complete training of a competitor in any sport or game, and should include a dissertation on training as well as on all injuries and diseases. The more serious of these failures, such as fractures of bones, severe sprains of joints, badly torn muscles or nerves, or cerebral concussion, should pass immediately into specialist hands; but a host of lesser failures remains with the practitioner and is the source of much sick wastage with time lost from competition.

Experimental Air-Borne Tuberculosis and Its Control. Max B. Lurie.

Am. Rev. Tuberc. 55:124 (Feb.) 1947.

Methods of studying both natural and quantitative air-borne contagion of tuberculosis in rabbits and guinea pigs are described. The effect of the number of respired tubercle bacilli on rabbits of high and low genetic resistance to the disease is outlined. Resistance to attack by natural air-borne contagion is distinguished from the resistance to the progress of the engrafted disease.

Ultraviolet light kills tubercle bacilli suspended in the air. Experiments are described whereby suitable ultraviolet irradiation of the air completely protected rabbits from an air-borne contagion of tuberculosis of such intensity which killed 73 per cent of rabbits of the same genetic constitution, exposed to the same contagion within the same period of one year.